A neurodevelopmental movement programme for 4-8 year old hearing impaired children in the rural QwaQwa region of South Africa

Jó-MARIé VAN DER MERWE BOTHMA
23240865

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PROMOTOR: Dr. M. Dunn
CO-PROMOTOR: Prof. S. Kokot

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SUMMARY

Being hearing impaired does not only affect a child's academic performance, but can also influence a child's overall development and ability to succeed academically. Evidence suggests that the outlay in early childhood has a large impact on a child's readiness to learn. Neurodevelopmental movement programmes are generally not accepted as evidenced-based practice and their effect on academic performance is often underrated. Movement, however, is regarded by many as essential to learning and there seems to be a positive interchange between the brain and the body.

This study reports on the influence of a neurodevelopmental movement programme on the development, behaviour and performance on a neurodevelopmental evaluation scale of four to eight year-old children with hearing impairment children. The study furthermore provides a report of the results of the psychometric assessment in the form of a neurodevelopmental profile for this specific sample. Children were selected from a special needs school in the rural QwaQwa Free State area of South Africa. Two groups of children (an experimental and comparison group) were used in this study, with both groups undergoing a pretest and posttest phase using three test batteries (Griffiths Mental Developmental Scales- Extended Revised, Child Behaviour Checklist, and a neurodevelopmental evaluation scale). The experimental group was subjected to a fourteen-week neurodevelopmental movement programme. The comparison group underwent a placebo intervention. The results indicate that the children in the experimental group showed an improvement in some aspects of specific development following the intervention (locomotor functioning, performance related abilities, and practical reasoning skills). General developmental age showed significant improvement in both the experimental group and the comparison group. No behavioural aspects showed significant improvements following the intervention, whereas some neurodevelopmental aspects, such as the vestibular system (Tandem Walk and One Leg Stand) and the reflex system (TLR – reflex) showed significant improvements. The results of this empirical investigation aid in understanding the impact of movement programmes on a child with hearing disability's general development and neurodevelopmental development.

KEY TERMS

Neurodevelopment

Neurodevelopmental movement programme

Sensory motor subsystems

Hearing impairment

Movement

DECLARATION OF TERMS

Within the context of the study:

- The masculine and feminine form of the pronoun is used interchangeably during the literature review and refers throughout to both sexes, except where specifically indicated otherwise.

- The term ‘children’ is used interchangeably with ‘learners’ when referring to an educational setting.

- The term ‘hearing impairment’ is used interchangeably with ‘hearing loss’, ‘hearing disability’ and ‘deaf’.

- The researcher used the past tense in all references to the research process because the research report was finalised after the research process was completed. Referrals to other authors and research studies are generally made in the present tense, depending on the context of the statement, because these statements were seen as still applicable.

- The author of this study is referred to as the researcher.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS (i)

SUMMARY (iii)

KEY TERMS (iv)

DECLARATION OF TERMS (v)

TABLE OF CONTENTS (vi)

LIST OF ADDENDA (xii)

LISTS OF FIGURES AND TABLES (xiii)

CHAPTER 1: Introduction and Overview of Study 1

1.1 Introduction 1

1.2 Problem Statement and Motivation for the Study 9

1.3 Goal and Objectives of Research 10

1.3.1 Research Goal 10

1.3.2 Objectives 10

1.4 Hypotheses for the Study 11

1.5 Research Methodology 12

1.5.1 Research Approach 12

1.5.2 Research Design 13

1.5.2.1 The Social Problem and the Sample 14

1.5.2.2 The Comparison Group Pretest-Posttest Design 16

1.5.2.3 Data Analysis and Dissemination 17

1.6 A Brief Definition of Key Terminology 18

1.6.1 Hearing Impairment 18

1.6.2 Movement 18

1.6.3 Neurodevelopmental Movement Programme 19

1.6.4 Neuroplasticity 19

1.7 Ethical Aspects 19

1.7.1 Avoiding Harm to the Learners 20

1.7.2 Informed Consent and Voluntary Participation 20

1.7.3 Deception of the Learners 21

1.7.4 Violation of Privacy and Confidentiality 22

1.7.5 Actions and Competence of the Researcher 22

1.7.6 Release of the Findings 22
1.8 Contextualization of the Study 23
1.9 Conclusion 24

CHAPTER 2: The Auditory System and Hearing Impairment 25
2.1 Introduction and Chapter Preview 25
2.2 The Structure of the Ear and the Auditory System 25
2.3 Development and Process of Hearing 31
2.3.1 The Mechanism of Sound 32
2.3.1.1 Frequency 33
2.3.1.2 Intensity 34
2.3.1.3 Complexity 34
2.3.2 The Audiogram and Hearing Assessment 35
2.4 Disability and Impairment 38
2.4.1 Hearing Impairment 39
2.5 Incidence and Prevalence of Hearing Impairment 42
2.6 Classification of Hearing Loss 44
2.6.1 The Age of Onset of the Hearing Loss in Relation to Language and Speech Development 44
2.6.2 The Location of the Loss in the Ear 45
2.6.2.1 Conductive Hearing Loss 45
2.6.2.2 Sensorineural Hearing Loss 47
2.6.2.3 Mixed Hearing Loss 49
2.6.3 The Cause of the Hearing Loss 49
2.6.3.1 Prenatal-or Congenital Hearing Causes 50
2.6.3.2 Perinatal Causes 53
2.6.3.3 Postnatal Causes or Acquired Disorders 53
2.7 Amplification 55
2.7.1 Children and Hearing Aids 57
2.8 Education, Language and Communication in Children with Hearing Impairment 58
2.8.1 Auditory-Oral and Auditory-Verbal Approaches 61

2.8.2 Total Communication (TC) 62
2.8.3 Sign-Bilingualism Approach 62
2.9 The Impact of Hearing Impairment 64
2.9.1 Hearing Impairment: Social and Emotional Development 65
2.9.2 Hearing Impairment: Language and Cognitive Development 67
2.9.3 Hearing Impairment: Behaviour Difficulties 68
2.10 Conclusion 70

CHAPTER 3: Child- and Neurodevelopment 71
3.1 Introduction and Chapter Preview 71
3.2 Developmental Constructs 72
3.3 The Development of the Child 77
3.3.1 Neurodevelopment 77
3.3.1.1 The Development of the Nervous System and the Human Brain 78
3.3.1.2 The Organisation of the Nervous System 82
3.3.1.3 Neuron Cells and Myelination 96
3.3.2 Locomotor Development 109
3.3.2.1 The Reflexive / Spontaneous Movement Phase 110
3.3.2.2 The Rudimentary and Fundamental Movement Phase 116
3.3.3 Personal-Social Development 119
3.3.3.1 Erikson's Psychosocial Theory 120
3.3.3.2 Social and Emotional Development and the Hearing Impaired Child 122
3.3.4 Cognitive Development 124
3.3.4.1 Piaget's Cognitive Developmental Theory 124
3.3.4.2 Vygotsky's Sociocultural Theory and the Information Processing Perspective 128
3.3.4.3 Cognitive Development and the Child with Hearing Impairment 129
3.3.5 Language and Communication Development 133
3.3.5.1 Language Development and the Child with Hearing

Impairment 136
3.3.5.2 A Critical Period in Acquiring Language 139
3.4 Conclusion 142

CHAPTER 4: The Neurodevelopmental Basis of Human Movement and Movement Interventions 144
4.1 Introduction and Chapter Preview 144
4.2 Perceptual and Sensory Motor Concepts 145
4.2.1 Differentiation 145
4.2.2 Lateralisation, Midline and Directionality 147
4.2.3 Interhemispheric Integration 150
4.2.4 The Sensory Motor System 151
4.2.4.1 The Vestibular System: Motion and Balance 153
4.2.4.2 The Proprioceptive System and the Term Kinaesthesia 159
4.2.4.3 The Tactile and the Auditory Systems 161
4.2.4.4 The Visual System 164
4.3 The Integration of Neurological Subsystems and Movement 173
4.3.1 The Importance of Movement and Learning 180
4.4 Conclusion 186

CHAPTER 5: Research Methodology: The Empirical Investigation 188
5.1 Introduction and Chapter Preview 188
5.2 Goal and the Hypotheses of the Research 189
5.3 Research Method and Design 191
5.3.1 The Comparison Group Pretest-Posttest 192
5.3.2 Selection of the Sample 194
5.3.3 The Validity of the Research 195
5.3.3.1 External Validity 195
5.3.3.2 Internal Validity 196

5.4 Measuring Instruments Used in the Empirical Investigation 199
5.4.1 Biographical Questionnaire 201
5.4.2 Griffiths Mental Developmental Scales – Extended Revised (GMDS-ER) 201
5.4.2.1 Administration and Scoring of the GMDS-ER 205
5.4.3 The Child Behaviour Checklist (CBCL) 206
5.4.3.1 Administration and Scoring of the CBCL/6-18 (TRF) and CBCL/1 ½-5 (C-TRF) 212
5.4.4 The Neurodevelopmental Evaluation Scale (NES) 213
5.4.4.1 The Vestibular System – Coordination and Balance 215
5.4.4.2 The Visual System 216
5.4.4.3 The Reflex System 218
5.5 Data Collection 218
5.5.1 Procedure 218
5.5.2 Pretest Procedures 218
5.5.3 The Intervention: The Neurodevelopmental Movement Programme 220
5.5.4 Posttest Procedures 224
5.5.5 Finalizing the Research Project at the School 224
5.6 Data Interpretation 225
5.7 Conclusion 225

CHAPTER 6: Research Results and Interpretation 227
6.1 Introduction and Chapter Preview 227
6.2 Data Analysis 227
6.2.1 Descriptive Statistics 227
6.2.2 Inferential Statistics 228
6.2.3 Methods of Analysis 229
6.3 Sample Description 230
6.3.1 Demographic Description 230
6.3.2 Family Structure 232
6.3.3 Historical and Scholastic Background 234
6.3.4 Developmental Presentation 237

6.4 Testing the Hypotheses 239
6.4.1 Effect of the Programme on the GMDS-ER (H1) 241
6.4.1.1 Summary of GMDS-ER Analysis 249
6.4.2 Effect of the Programme on the CBCL (H2) 250
6.4.2.1 Summary of CBCL Analysis 254
6.4.3 Effect of the Programme on the NES (H3) 254
6.4.3.1 Summary of NES Analysis 263
6.5 Results in the Form of a Neurodevelopmental Profile of this Specific Sample 264
6.6 Conclusion 267

CHAPTER 7: Limitations, Recommendations and Conclusions 269
7.1 Introduction 269
7.2 Discussion of Results 269
7.2.1 Improvement of Development 269
7.2.2 Improvement of Behaviour 272
7.2.3 Improvement on the Performance of the Neurodevelopmental Evaluation 273
7.3 Programme and Study Evaluation 275
7.4 Influence of Variables and Limitations of the Study 279
7.5 Suggestions and Recommendations for Future Research 281
7.6 Conclusion 283

REFERENCES 286

LIST OF ADDENDA

ADDENDUM A:

Covering letter and consent form to parents requesting participation

ADDENDUM B:

Biographical Questionnaire

ADDENDUM C:

Neurodevelopmental Evaluation Scale

ADDENDUM D:

Programme Activity Monitoring

ADDENDUM E:

Consent Form from School Principal

ADDENDUM F:

Approval from Education Department

LISTS OF FIGURES AND TABLES

FIGURES

Figure 2.1	Anatomy of the ear	26
Figure 2.2	Auditory Pathways	29
Figure 2.3	Breaking Down Sound	33
Figure 2.4	Normal Hearing	35
Figure 2.5	Audiogram with Speech- and Ordinary Sounds	37
Figure 2.6	Audiogram Indicating Different Types of Hearing Loss	47
Figure 2.7	Genetic and Environmental Contributions to Congenital Sensorineural Hearing Loss	52
Figure 2.8	Different Types of Hearing Aids	57
Figure 3.1	Formation of the Neural Plate and the Neural Tube	79
Figure 3.2	Progression of Brain Growth From Four Weeks After Conception to Birth	81
Figure 3.3	The Human Brain	82
Figure 3.4	Somatosensory and Motor Cortex	85
Figure 3.5	Anatomical Divisions of the Human Nervous System	88
Figure 3.6	Functional Divisions of the Human Nervous System	92
Figure 3.7	The Brain – Side View	93
Figure 3.8	The Neuron	97
Figure 3.9	Dendrite Density Development	98
Figure 3.10	Two Neurons Forming a Synapse	99
Figure 3.11	Electrical Impulses and Neurotransmitters	106
Figure 3.12	Phases of Motor Behaviour	110
Figure 3.13	Primitive Reflex Profile	113
Figure 3.14	Interactionist Perspective on Language Development	135
Figure 4.1	Structure of the Human Ear	154
Figure 4.2	Vestibular System	155
Figure 4.3	The Human Eye	167
Figure 4.4	Visual Pathways	169
Figure 4.5	Sensory-Motor Interdependency and Interaction	175
Figure 4.6	The Ladder of Learning	177

Figure 4.7	The Pyramid of Learning	178
Figure 4.8	Interrelated Systems Chart	179
Figure 4.9	Synapse Formation in the Developing Brain during Sensitive Periods of Development	181
Figure 5.1	Research Design	199
Figure 6.1	Gender Composition of the Sample (N = 18)	231
Figure 6.2	Grade Composition of the Sample (N = 18)	232
Figure 6.3	Family Structure of the Sample (N = 18)	233
Figure 6.4	Employment Status of Participants' Parents (N = 18)	234
Figure 6.5	Cause of Participants' Hearing Loss (N = 18)	235
Figure 6.6	Participant Age at Diagnosis of Hearing Loss (N = 18)	236
Figure 6.7	Participants' Age at School Entry (N = 18)	237
Figure 6.8	Representation of Analysis: Within Group and Between Group Effects	240
Figure 6.9	Group*Time Interaction According to the Developmental Age Subscale of the GMDS-ER	244
Figure 6.10	Group*Time Interaction According to the Locomotor Subscale of the GMDS-ER	245
Figure 6.11	Group*Time Interaction According to the Performance Subscale of the GMDS-ER	248
Figure 6.12	Group*Time Interaction According to the Practical Reasoning Subscale of the GMDS-ER	249
Figure 6.13	Group*Time Interaction According to the Tandem Walk Activity of the NES	257
Figure 6.14	Group*Time Interaction According to the One Leg Stand Acivity of the NES	259
Figure 6.15	Group*Time Interaction According to the ATNR Reflex Activity of the NES	261
Figure 6.16	Group*Time Interaction According to the TLR Reflex Activity of the NES	262
Figure 6.17	Hearing Impaired Profile (developmental age in months on the GMDS-ER)	265

TABLES

Table 2.1	Guidelines used to describe degrees of hearing impairment in Children	40
Table 2.2	Degree of Hearing Loss	41
Table 2.3	Percentage of People with Disability Affected by a Hearing Impairment According to Cultural Group	43
Table 2.4	People with Disabilities in the Free State by Population Group	43
Table 3.1	A Chronological Overview of Human Development	73
Table 3.2	Cranial Nerves Overview	89
Table 3.3	Erikson's Stages of Psychosocial Development	120
Table 3.4	Piaget's Stages of Cognitive Development	126
Table 5.1	Measuring Instruments	201
Table 5.2	Six Subscales of the GMDS-ER	204
Table 5.3	Syndrome Scales of the CBCL/6-18 (TRF)	208
Table 5.4	Syndrome Scales of the CBCL/1½ -5 (C-TRF)	210
Table 5.5	Time Frame and Procedures of the Research Study	218
Table 5.6	The List of Activities of the "Wired to Learn" Movement Programme	223
Table 6.1	Descriptive Information on Age of the Sample (N = 18)	231
Table 6.2	Parents' Level of Education (N = 17)	233
Table 6.3	Comorbid Disorder of Participants (N = 18)	235
Table 6.4	Participants' General Developmental Level of Functioning (N = 18)	238
Table 6.5	Participants' Specific Developmental Levels of Functioning (N = 18)	238
Table 6.6	Significance of Difference Between Groups on the GMDS-ER (Interaction Effect)	242
Table 6.7	Significance of Difference Within Groups on the GMDS-ER	243
Table 6.8	Significance of Difference Between Groups on the CBCL (Interaction Effect)	251
Table 6.9	Significance of Difference Between Groups on the NES (Interaction Effect)	255
Table 6.10	Significance of Difference Within Groups on the NES	256
Table 6.11	Hearing Impaired Profile (mean activity scores on the NES)	266

CHAPTER ONE

INTRODUCTION AND OVERVIEW OF STUDY

1.1 INTRODUCTION

Early investigations into the young child with hearing impairment's cognitive functioning usually concluded that these children were cognitively inferior and show a lag of several years in terms of their mental functioning in comparison to their hearing peers (Furth, 1964; Lister, Leach & Wesencraft, 1988; Pintner & Patterson, 1917). Early researchers suggested that neuropsychological differences between children with hearing loss and hearing children might result in qualitatively different styles of information processing (Tomlinson-Keasey & Kelly, 1978). Marschark (1993a:149) confirmed that alternative information-processing styles were probably the reason for differences in performance in academic settings, and that such differences will have implications for achievement and success across various domains.

Over the years, writers and researchers attest to the fact that being hearing impaired does not only affect a child's academic performance, but can also influence a child's emotional, language, perceptual, psychosocial, mental and motor development (Allen, Cowdery & Johnson, 2012:123; Altshuler, 1974; Braun, 1990:28; De Swardt, 1990:29; Huttunen, 2001; Landreth, Sweeney, Ray, Homeyer & Glover, 2005:69, Marschark, 2003:465). Comorbid disorders in children with hearing loss, such as attention deficit disorder, hyperactivity, emotional problems, mild to severe learning disorders, neurological immaturity, autism, as well as eye problems may be related to specific neurodevelopmental delays in, for instance, perceptual motor functioning (Ittyerah & Sharma, 1997; Knoors & Vervloed, 2003:82; Marschark, 1993a:14; Waldman & Roush, 2005:41). Ittyerah and Sharma (1997) state that perceptual motor functioning delays may in turn impact on the eye-and-hand coordination skills of some children with hearing loss. As a result, children with hearing impairment may be clumsier in handling objects, which in turn can affect the child's perceptual motor coordination. Marschark (1993a:239) recommends that more empirical research on neuropsychological relationships of deafness and on methods of education is needed. Wilson (1998:52)

adds that as children with hearing impairment often experience delays in other areas of their development, it is important to design intervention programmes as part of a school curriculum to address all these aspects, and thus minimise the impact on a child's overall development. Such programmes can aim to minimise the negative impact of the hearing impairment on a child's overall development. Kruger, Kruger, Hugo and Campbell (2001) reported research results that highlighted the integration of problem areas that some children experience. These researchers selected 19 children of mixed gender and grouped them according to their problems. They identified children sharing visual, auditory, as well as problems with motor functioning and concentration difficulties. Their results pointed to the neurophysiological ***integration of sensory and motor systems***, which weighs heavily in the development of academic success. Kruger *et al*.'s (2001) study is significant as it encompassed multidisciplinary areas of expertise and did not fragment the difficulties that children often experience together. The current thinking remains that early intervention is important to enhance many aspects of a child with hearing impairment's development and later academic achievement (Marschark & Hauser, 2012:59).

In South Africa, psychotherapeutic research on children with hearing loss appears to mainly focus on therapeutic techniques and concludes that family therapy, art therapy, Theraplay®, Gestalt play therapeutic mediums, and developmental play therapy all have a positive influence on the preschool or young hearing impaired child's behaviour; and can improve the interaction between a therapist and child with hearing loss in treating emotional problems and in preparation for formal schooling (Daling, 1984:157; De Wet, 1993:215; Erasmus, 1984:231; Pauw, 2002; Van der Merwe & Schoeman, 2001). Some of the intervention research in the South African context emphasises communicative intervention programmes, how to improve the writing of children with hearing impairment, support for families of the deaf, the importance of early diagnoses, enhancing specific resilience qualities to help protect and support families, and identifying the needs which must be met to address the development of full-service schools to include learners with hearing loss (Ahlert, 2009:178; Hurt, 2005; Noorbhai, 2002; Retief, 2006:16; Storbeck & Calvert-Evers, 2008; Weir, 2010:i). In her evaluation

of the developmental performance of a sample of urban South African children with hearing loss aged three to seven, Schröder (2004:54) proposed that all children with hearing loss be exposed to as much stimulation as soon as possible so that their sensory deficit does not become a restricting factor in their overall development. Rossi (2005:106) postulates that the preschool stage of development is a critical time when children with delayed development will benefit the most from intervention. This opinion is supported by an educational specialist at the University of West England, Mary Mountstephen (2011:68). She states that early detection and intervention for delays are vital in altering developmental learning trajectories for children. This will have the subsequent benefit of more efficient and greater complexity of later learning.

In South Africa, children should be in Grade One (foundation phase) by the year they turn seven. South African educational policy also permits a child who is five years old and turning six by 30 June to be admitted to Grade One (South Africa, 2007:2; Department of Basic Education, 2012) if they are shown to be ready for school (Western Cape Government, 2012). A screening test for younger children is used to determine their readiness for formal schooling (Western Cape Government, 2012). Some children will not be developmentally ready for formal schooling, irrespective of the age they start school (Mountstephen, 2011:67). According to Mountstephen (2011:68), many children entering formal schooling have not yet developed the skills for learning. A South African study explored the nature, incidence and factors of learning problems among 800 Grade Three learners (mixed races in inclusive schools) from 11 schools in the Tshwane Metropolitan Municipality, Gauteng Province. The results showed that 50.5% of 634 foundation phase learners experienced moderate to severe learning difficulties or disabilities. The most commonly experienced difficulties were with concentration, completion of tasks, reading, and low muscle tone. Of the sample population, 24.4% experienced problems during their preschool years (Kokot, 2006).

It is likewise reported that some children in the black and rural communities in South Africa are not adequately prepared for formal schooling, and as a result are not ready to learn when they enter Grade One (Fiske & Ladd, 2004:244; Louw, van Ede & Louw,

1998:262; Van Rooyen & Engelbrecht, 1997). In September 1997 a four-day conference was hosted in South Africa with the theme: "*Developing quality schools in rural areas*". The conclusion reached was that the state of rural schooling was not adequately addressed and still needed attention. As a result of past racist policies, these inequalities were more evident in rural areas (Gordon, 1997:2; Seroto, 2004:1). South Africa's rural communities remain disadvantaged compared to their counterparts in urban areas and the need to work with the rural communities in their development is considered critical (South Africa, 2005:7-8). The need for redress required in rural areas is significantly higher than in urban areas (Department of Education, 2005:11). Added to this, the South African government emphasises the need for children who suffer from hearing loss to experience improvements and benefits in their quality of life and education (Tshabalala-Msimang, 2007). In this study, the researcher therefore felt it necessary to include preschool and foundation phase children between the ages of four and eight years, as this phase appears to be critical in preparing children for formal schooling. The study also particularly focused on black learners in a rural community in South Africa, specifically the rural QwaQwa district (also referred to as Phuthaditjhaba) in the Free State Province, as rural areas remain disadvantaged with regards to educational programmes for disabled children.

The researcher's special interest in neurodevelopment and involvement in stimulation programmes for babies, toddlers and children inspired this study. The main motivation for attempting this study on ***neurodevelopmental movements*** *(activities and movements that can stimulate perceptual, sensory and motor systems important for learning)* is foremost born from the researcher's experience as an Integrated Learning Therapy practitioner[1], where learning difficulties are addressed through movement-based programmes in one-on-one therapeutic sessions and school programmes. Through five years' experience in neurodevelopmental movement interventions and eight years as a psychologist, the researcher was intrigued by the possible value of movement-based intervention as a practical and affordable way of optimising a learner's potential.

[1] The Centre for Integrated Learning Therapy (ILT) was founded by Prof. Shirley Kokot and brings together knowledge and practice from various developmental and neurodevelopmental psychology fields to address behaviour and learning difficulties (www.ilt.co.za).

There is a dearth of research exploring the effect of neurodevelopmental movement programmes on children with hearing impairment's development (HANDLE®, 2009a, Kokot, 2009). Movement programmes are additionally not generally accepted as evidence-based practice and more critical thinking and higher standards of evidence are recommended (Hyatt, Stephenson & Carter, 2009). Although the link between movement and successful learning originates from earlier theorists (Ayres, 2005:75; Delacato, 1974:41; Kephart, 1971:27, 262), Fredericks, Kokot and Krog (2006) note that research does not always show that movement programmes are helpful in learning. Kavale and Mattson (1983) conducted a meta-analysis of 180 studies of ***perceptual motor programmes*** *(particularly prescribed motor activities and exercises to enhance integration of sensory input with motor responses)* and found a very small overall effect size, suggesting that the programmes examined had little impact on reading, intelligence and general achievement, and even on perceptual-motor skills themselves. Smith, Mruzek and Mozingo (2005:345) state that ***sensory integration therapy*** *(range of activities that typically include the combination of controlled sensory stimulation and purposeful motor activity)* is ineffective and that its theoretical underpinnings and assessment practices are invalidated.

In the early 1980s, Dr. Dennison, a remedial educational specialist, founded the field of educational kinesiology (Edu-K), which he defined as "learning through movement" (BrainGym®, 2008). Movement programmes such as the BrainGym® repetitions are designed to integrate body and mind in order to improve concentration and focus, memory, reading, writing, physical coordination, relationships, self-responsibility, organisational skills and attitude. The theoretical foundations of such programmes remain largely controversial (BrainGym®, 2011). The programme has been criticised as pseudoscience for the lack of clear references for some of its theories and the absence of peer review research that supports the effect of the activities on academic performance, and the programme's claims have been ascribed to the placebo effect (Diamond, 2007:15; Goswami, 2006; Hyatt, 2007). In a South African doctoral study (De Jager, 2005:3), a BrainGym® programme was implemented for a period of six weeks on 81 Grade One hearing pupils and evaluated by means of quantitative and qualitative

data. The inferential statistics yielded no significant results, suggesting that the BrainGym® intervention did not have a measureable effect on the sample's scores on subtests of the Aptitude Test for School Beginners (ASB). However, qualitative data indicated a noticeable improvement in aspects such as crossing the visual midline, eye-and-hand coordination, logic and gestalt brain integration, self-image, mathematical computation and concentration. The discrepancy between the quantitative and qualitative findings was understood in the context that emotional and physical development would be more noticeable within the shorter time span of six weeks, unlike academic improvement (De Jager, 2005:3, 286, 330). In another South African study, six to eight year-old hearing children who participated in an eight-week kinderkinetic programme showed significant improvement in measures of motor proficiency, scholastic performance and classroom behaviour (Gouws, 2009:82). In 2011, Channel 4 News (news division of British television broadcaster) aired a show with biologist and award winning educator and author Dr. Carla Hannaford (Hannaford, 2005). She discussed how inactivity can lead to learning difficulties and she explained how BrainGym® movements can activate brain and body connections, helping students to think and attend better (Channel 4 News, 2011).

Sally Goddard-Blythe (Goddard, 2009:4-5) is well-known and respected for her work on the links between primitive, postural reflexes and learning and recently published a book, *Attention, Balance and Coordination: The ABC of Learning Success* (Goddard, 2009:4-5), in which she explores the physical basis for learning. She stresses that there are links between successful academic learning and the adequate mastery of motor skills. These theories also underlie the Primary Movement Programme (2006), with several published papers supporting its efficacy (e.g., Brown, 2010; Jordan-Black, 2005; McPhillips, Hepper & Mulhern, 2000; McPhillips, 2001; McPhillips & Sheeby, 2004; McPhillips & Jordan-Black, 2007a, 2007b). However, Hyatt *et al*., (2009) note that two of these research studies (Jordan-Black, 2005; McPhillips *et al*., 2000), which report positive effects on reading and mathematics, have limitations and therefore need to be replicated by other researchers prior to acceptance. Numerous other professionals, educational programmes and researchers also consider the brain and the body as a

united whole and believe that the body, via sensory-motor responses, causes the brain to learn and thus to organise the self (Cheatum & Hammond, 2000:1-2; De Jager, 2006:vii; De Jager, 2009:3; Dore, 2012; Goddard, 2011:8-9; Hannaford, 2005:21-22; Kokot, 2003a; Pica, 1998; Primary Movement Programme, 2006). There is a growing body of evidence that the control of balance, motor skills and the integration of early reflexes are linked to academic achievement (Mountstephen, 2011:71).

Benefits from other developmental movement programmes have been witnessed in research studies and anecdotal writings. These include decreased levels of hyperactive behaviour and increased attentiveness with hyperactive, distractible and aggressive children (Suliteanu, 2005:4), increased regional cerebral blood flow in chronic traumatic brain injury (Lewis, Bluestone, Savina, Zoller, Meshberg & Minoshima, 2006:276*)*, and better eye contact and verbal communication in children with autism spectrum disorders (HANDLE®, 2009a). Goddard Blythe (2000) states that opportunities for movement and physical education are as important as the teaching of literacy and mathematics, especially in the early learning years. The effectiveness of a developmental exercise programme with 810 children with special needs (aged four to ten years) was investigated in two schools in Ireland, with results indicating a significant increase in performance in literacy (Goddard Blythe, 2005). In South Africa the success of a neurodevelopmental approach for helping children with barriers to learning was illustrated by means of two case studies (Kokot, 2005). An explorative South African study reported on a developmental movement programme that was established in an attempt to determine whether movement would improve the academic skills of Grade 1 learners. The research results showed a significant improvement in spatial development, reading and mathematical skills in the experimental group compared to the learners in a control group, a free-play group and an educational toys group (Fredericks *et al*., 2006). A more recent South African study provided significant insight into understanding the impact of a movement programme on the degree of learning readiness. Movement was found to constitute a vital key to learning readiness, early academic achievement, and neurological development of the child (Krog, 2010:92).
Dr. John Ratey (Ratey & Hagerman, 2008), a professor of psychiatry at Harvard Medical

School, puts forward the case that exercise improves attention, motivation, executive function skills and decreases anxiety. Ratey found that children expressed views that exercising before class and moving during class made schoolwork seem easier (Mountstephen, 2011:78). For some children, the physical exercises may not be sufficient because they do not address the child's level of developmental need. Mountstephen (2011:78) explains that if there are primitive and postural reflex problems which are affecting the child's ability to function to their best potential, movement strategies may not work effectively, because they are targeted at too high a level in terms of brain development. Such children may need a more basic level of developmental intervention. There is a difference between regular physical movements as opposed to sensory and perceptual motor programmes. It is only in the case of the latter that a significant difference is seen in academic performance and related social skills (Fredericks *et al*., 2006). Accordingly, the developmental movements in this study were selected and implemented in an attempt to stimulate neurological systems. These activities were drawn from those included in the ILT (*Integrated Learning Therapy*) approach (ILT, 2005) of which the *HANDLE*® approach and the *Move to Learn* approach form an integral component (HANDLE®, 2009b; Move to Learn, 2012a).

Conflicting opinions and a lack of empirical studies have professionals in doubt about the effectiveness of neurodevelopmental approaches in aiding overall development and learning. Some theorists believe that neurological systems needed for development and optimal functioning are stimulated by movement, while others consider movement to have no significant impact on academic performance or neurodevelopment (Corrie & Barratt-Pugh, 1997:30; Hyatt *et al*., 2009; Leary, 1997). The rationale for including movement programmes in a multidisciplinary approach should therefore be based on a sound understanding of their relevance. Considerable (national and global) empirical work is needed to test the validity of claims made by neurodevelopmental practitioners (Kokot, 2005).

In an attempt to contribute to scientific research and the building of theory on this controversial topic, this research study focused on the selection and implementation of

neurodevelopmental movements to explore whether such movements influenced children with hearing impairment's performance on a developmental test, a neurodevelopmental evaluation scale, and a behaviour checklist. The results were then used to design guidelines for educators in their use of developmental movement programmes to enhance development in children with a hearing disability.

1.2 PROBLEM STATEMENT AND MOTIVATION FOR THE STUDY

In our competitive world it is vitally important to have a well-educated and healthy population. Copley and Friderichs (2010) feel that this is even more important for a developing nation such as South Africa. They add that the capacity of children with hearing loss in South Africa to learn, to become skilled and to be able to communicate well are all vital qualities needed so that they can become meaningful contributors to our society. Striving for this goal should be one of the main concerns for the South African health, education and social services. This view is supported by evidence that the outlay in early childhood has a large impact on a child's health and readiness to learn. The result of this is significant returns in later life, even greater than investments in official education or training (World Bank, 2006:11). Apart from the early identification of hearing loss, suitable interventions and stimulation to enhance children's readiness to learn can go a long way in achieving these goals.

Children with hearing impairment's overall development are influenced by their disability, and can negatively impact on their academic, social, emotional and perceptual functioning. The lack of stimulation can lead to their sensory deficit becoming a restricting factor in their overall development and academic performance. South African professionals have the daunting task of reaching out to previously disadvantaged communities where children with disabilities rarely had the opportunity to experience educational intervention in preparation for formal schooling.

More knowledge and research is needed in the rural South African context with regard to the implementation of developmental movements, the influence of such movements on the development of children with hearing loss, as well as guidelines for the use of such

movement programmes to enhance development. Despite the potential value of neurodevelopmental movements, the extent of their worth is unknown and frequently viewed as unscientific (Hyatt, 2007). A neurodevelopmental approach may enhance development in children with hearing loss and may offer a cost-effective and time-efficient intervention method to implement in a school curriculum.

1.3 GOAL AND OBJECTIVES OF RESEARCH

The terms “goal”, “purpose” and “aim” are often used interchangeably and may be regarded as synonyms. The meaning of these terms implies the ends, means or the intent of the research project (Fouché & De Vos, 2005a:104; Houser, 2012:90). Babbie (2010:115) describes the purpose of a study in line with the kind of project that will be undertaken, such as explorative, descriptive or explanatory. The purpose of a study also refers to the reason for wanting to gain information. Reasons could include finding information to support theories or arguing for or against opinions.

An “objective” denotes the steps one has to take in order to attain the goal of the project and often describes the direction of the inquiry (Dawson, 2002:56; Houser, 2012:90). Objectives delineate therefore the intention of the researcher and the nature and the process of the investigations (Rubin & Babbie, 2011:595; Walliman, 2006:37).

1.3.1 Research Goal

The primary goal of this study was to implement, evaluate, and to design guidelines for a neurodevelopmental movement programme for four to eight year-old children with hearing impairment in a rural South African community.

1.3.2 Objectives

The specific objectives were:

- To provide a theoretical foundation for the implementation of a neurodevelopmental movement programme for children with hearing impairment through a literature review of the child with hearing impairment (especially in a rural community); neurodevelopmental systems involved in overall development; and

neurodevelopmental movement interventions

- To implement a neurodevelopmental movement programme based on developmental movements and activities in order to stimulate the integration of primary reflexes and the optimal functioning of sensory-motor systems that support human functioning for a period of 14 weeks to an experimental group of children with hearing impairment
- To ascertain if there are statistically significant differences between the pre-intervention and the post-intervention test scores on the
  - Griffiths Mental Development Scales – Extended Revised (GMDS-ER)
  - Child Behaviour checklist (CBCL)
  - Neurodevelopmental Evaluation Scale (NES)
- To report the results of tests in the form of a neurodevelopmental profile for the specific sample by reviewing the results on the developmental subscales of the GMDS-ER and the activities of the NES
- To describe the results comprehensively in order to propose guidelines and make recommendations for research and practice, as well as for theory building purposes on this particular group of children

1.4 HYPOTHESES FOR THE STUDY

Research investigates hypotheses with a view to either supporting or rejecting them. A hypothesis is a specific testable probability about an experimental reality (Babbie, 2010:46). Hypotheses are statements about the relationship between variables and carry clear implications for testing the stated relations. Upon testing the hypothesis, the theory from which it is derived is also tested (De Vos, 2005a:34). The following broad hypotheses were formulated as directive questions to the research and were applicable to the pre- and post-intervention testing:

Hypothesis 1:

H0: The movement programme does not improve the experimental group's **development** significantly.

H1: The movement programme does improve the experimental group's **development**

significantly.

Hypothesis 2:

H0: The movement programme does not change the experimental group's **behaviour** significantly.

H1: The movement programme does change the experimental group's **behaviour** significantly.

Hypothesis 3:

H0: The movement programme does not change the experimental group's **performance on the neurodevelopmental evaluation** scale significantly.

H1: The movement programme does change the experimental group's **performance on the neurodevelopmental evaluation** scale significantly.

1.5 RESEARCH METHODOLOGY

1.5.1 Research Approach

This section will provide theoretical information in an operational manner about the methods, procedures and techniques used in the research approach. The two most recognised research approaches are the qualitative and the quantitative paradigms (Clark-Carter, 2010:5; Fouché & Delport, 2005:73). These two paradigms differ and draw on diverse strategies of inquiry (Creswell, 2003:179). The approaches usually differ with regards to the methods of data collection, the procedures adopted for data processing and analysis, and the style of communication of the findings (Kumar, 2005:17). Kumar (2005:12) goes on to explain that a structured approach to inquiry is usually classified as quantitative research, and unstructured as qualitative research. The choice of the research approach is usually determined by the aims of the inquiry and the use of the findings. The purpose of posing questions and testing hypotheses about social reality is more suited to a quantitative approach, whereas a qualitative approach is usually more focussed on constructing detailed descriptions of social reality. The research design in a quantitative approach is frequently standardised according to a fixed procedure and can be replicated. The qualitative approach is more flexible and

unique and evolves throughout the research process; and the design cannot exactly be replicated (Creswell, 2003:8; Fouché & Delport, 2005:75). Babbie (2010:23) adds that the essential distinction between these two approaches pertains to the collection of numerical and non-numerical data. An advantage of quantitative methods is that they aim to produce findings that are precise and generalisable. Conversely, qualitative methods emphasise depth of understanding, attempt to subjectively tap into the deeper meanings of human experiences and are intended to generate theoretically rich observations (Rubin & Babbie, 2011:71; 2012:40). This does not imply that quantitative methods are completely inflexible or that qualitative methods have no advanced planned procedures. It is more a matter of emphasis and will depend on the conditions and purposes of the research inquiry. Both methods are valuable and each provides useful information (Rubin & Babbie, 2012:41). Based on the hypotheses of the study, the analysis was geared to ascertain the magnitude of the variation between the pre- and posttest results. The researcher determined that it would therefore be important to quantify the variation in the pre- and posttest results.

A ***quantitative research approach*** was selected, as the data collected and analysed were primarily numerical and a standardised procedure was followed. This study can be defined as an inquiry, based on the measurement of numbers and analysis with statistical procedures, in order to determine whether a movement programme can cause change (Fouché & Delport, 2005:74). The research methodology is discussed in full in chapter five. A brief outline of the research design follows.

1.5.2 Research Design

The design of the study includes the plan or procedures to be followed in order to provide answers for the research objectives (Krog, 2010:74; Kumar, 2005:84). The current study can be classified as experimental research. ***Experimental*** research designs are considered to reside at the top of the evidence-based practice research hierarchy for questions about intervention effectiveness (Rubin & Babbie, 2008:251). Newcomer, Hatry and Wholey (2010:28) elaborate that an experimental research design tests the existence of a causal relationship by comparing outcomes for those randomly assigned to programme services with outcomes for those randomly assigned to

alternative services or no services. The current study can be classified as experimental research, which investigates and describes the impact of an intervention in an area where little is known about this kind of programme and its effect on the target population.

Two basic types of experimental research exist, namely ***true experiments*** and quasi-experiments. True experimental designs are more complex, use randomisation and compare two or more groups, where one of the groups (the experimental group) receives the intervention (Fouché & De Vos, 2005b:138-141; Monette, Sullivan & DeJong, 2011:268). ***Quasi-experimental*** designs are used to approximate experimental control in non-experimental settings (Fouché & De Vos, 2005b:138-141; Monette *et al*., 2011:268). The researcher lacks a degree of control and it is often necessary to select subjects from pre-existing groups as opposed to a random allocation of subjects (Fouché & De Vos, 2005b:138; Goodwin, 2010:363). Quasi-experimental designs do not randomly assign research participants to groups. This design includes a comparison group rather than a control group, and in this way provides more causal support for the intervention under investigation than studies without comparison groups (Manuel, Fang, Bellamy & Bledsoe, 2011:156).

The current research can be classified as quasi-experimental in nature as the researcher used a pre-selected group of children in the form of three classroom settings at a special school. There was no random assignment of subjects or participants, as the three classes were already organised as special classes with children presenting with a hearing impairment. All the children were in either Grade Pre-R, Grade R, or Grade One and were between the ages of four-and-a-half years and eight years during the course of the research study.

1.5.2.1 The Social Problem and The Sample

Hastings (in De Vos, 2005b:395) distinguished between social problems, which are conditions having a negative effect on large numbers of people, as opposed to personal problems, where the impact of the problem affects individuals rather than societies. Earlier in this chapter, the researcher established that the social problem refers not only

to the crucial need to support children with hearing loss in South Africa to become skilled, but also to the general lack of such support, particularly in rural areas of South Africa. Overcoming this problem can only be achieved through assisting children with hearing loss during early childhood through effective intervention and educational programmes that promote a readiness to learn. De Vos (2005b:398) emphasises the importance of discovering what others have done to understand and address the problem. The researcher therefore incorporated the following operations to adhere to these recommendations:

- A literature review was done on the hearing impaired child's development; existing movement programmes, existing research and relevant neuropsychological concepts. This provided the researcher with the necessary background and knowledge to design the programme and effectively implement the intervention.
- The researcher consulted with and incorporated the knowledge of neurodevelopmental experts in the field of education and movement programmes. Conversations were also held with the therapists and schoolteachers at the target school to obtain relevant information about the children's development and learning challenges.

The research problem addressed in this study also has bearing on other population groups. According to Dyer (2006:55), a *population* refers to a set of individuals who share a certain set of features, whilst a *universe* would refer to all possible potential subjects with those attributes. In this study, the universe was all four to eight year-old children with hearing impairment in rural South Africa, with the population being all the four to eight year-old children with hearing impairment in QwaQwa. The main reason that a sample is drawn from a population, according to Blaikie (2010:172), is practicability of cost and time. The researcher drew a nonprobability, purposive sample from the population by making use of a special school in the Free State Province, South Africa. The special school caters for deaf, blind and cognitively impaired learners and is situated in a rural area, namely QwaQwa.

Nonprobability *sampling* takes advantage of respondents who are already available (Morgan, Gliner & Harmon 2005:125). The selection process is partially subjective and the subjects are not chosen at random (Myers & Hansen, 2012:121). Babbie (1998:194) argues that during nonprobability sampling, it is not always possible to determine how representative the sample will be, therefore limiting the generalising of the results. However, it may still be possible to generalise to theory. This means that theories or models can still be developed or refined from studies conducted from nonprobability samples (Gratton & Jones, 2004:103). The reality is that despite the advantages of random selection, many quantitative studies are based on nonprobability sampling methods, as it is not always possible to identify everyone in the population and make use of random selection. It is generally too difficult and too costly to do so (Macnee & McCabe, 2008:123; Myers & Hansen, 2012:121). Purposive sampling was employed in this study, with the researcher using her judgement (Alston & Bowles, 2003:93) to select all the four to eight year-old children with hearing loss from a special school in a rural area who met the study requirements (Strydom, 2005a:202). These individuals reflected the specific purpose of the study (Myers & Hansen, 2012:122), and the selection of subjects was based on specific characteristics, such as being hearing impaired and living in a rural South African area (Macnee & McCabe, 2008:124). Again, the researcher is aware that generalising the results obtained from using a purposive sample should be done with extreme care, as such a sample is likely to include many unique characteristics that might limit the ability to generalise. Macnee and McCabe (2008:128, 130) state that the major advantage of a purposive sample is that selected factors are clearly defined and identified. Purposive sampling also makes it possible to locate a sample that might be relatively hard to recruit or identify.

1.5.2.2 The Comparison Group Pretest-Posttest Design

The comparison group pretest-posttest design was chosen to evaluate the effect of the developmental movement programme (Fouché & De Vos, 2005b:140). A comprehensive overview of this design is presented in chapter six. All children between the ages of four and eight first underwent assessment on the Griffiths Mental

Developmental Scales – Extended Revised (GMDS-ER), the Child Behaviour Checklist (CBCL) and a Neurodevelopmental Evaluation Scale (NES), after which children were then randomly assigned to either a comparison group or an experimental group. Children were selected from similar populations with regard to gender, age, level of hearing loss and social class.

The experimental group followed the movement programme on a daily basis for 14 weeks. The comparison group was either allowed to play freely, complete drawings and puzzles or use this time to finish classwork. Both groups were always accompanied and supervised by the trained occupational therapist or the researcher during those times. The comparison group was also given the opportunity to take part in the movement programme once the study was completed. After 14 weeks all children in both the comparison and experimental groups were reassessed on the GMDS-ER, CBCL and NES.

1.5.2.3 Data Analysis and Dissemination

The data were analysed in terms of the aims of the study. The analysis was performed by Professor M. Kidd of the Centre for Statistical Consultation at the University of Stellenbosch, South Africa. Frequencies and graphs were conducted to summarise the biographical details of the sample according to groups, for example, age, gender and degree of hearing loss. Data analysis furthermore typically included converting of all the pretest and posttest scores to a percentage, and the computation of means and standard deviations (Kruger, De Vos, Fouché & Venter, 2005:232). Decisions in terms of appropriate statistical methods were made in consultation with Professor Kidd. The data were analysed using STATISTICA (V10), a data analysis software package (StatSoft Inc., 2011). The data collection and analysis process is described in detail in chapter six.

During the final phase of the research process, the research findings and intervention materials are disseminated. This may also involve the publication of peer-reviewed articles in academic journals and may lead to an increase in the quality of the literature.

Several operations support this process of dissemination (De Vos, 2005b:404). For the purpose of this study, the researcher did the following:

- Prepared the product for dissemination by completing a professional educational write-up in the form of a doctorate dissertation
- Identified potential markets for the intervention. This entailed the identification of other special schools in rural areas with a similar population of children with hearing loss that could benefit from using the programme in their school. Part of the dissemination process could include the creation and publication of user-friendly treatment manuals. This would be particularly helpful in using the programme at other schools to ensure the proper implementation of the movements
- Created a demand for the intervention by introducing the intervention programme to similar school settings in rural areas
- Encouraged appropriate adaptation within limits to still guarantee the effectiveness of the programme

1.6 A BRIEF DEFINITION OF KEY TERMINOLOGY

The following terms were defined within the context of the study:

1.6.1 Hearing Impairment

Henderson (2006:920) defines *impairment* as any loss or abnormality of psychological, physiological or anatomical structure or function. In general, terms such as *deafness, Deaf* and *hard-of-hearing* are used to refer to individuals who have a hearing impairment or auditory disability of some degree. It is difficult to define *hearing impairment* per se, as the implications of the sensory disability vary from child to child (Schröder, 2004:19-22). For the purposes of this study the researcher uses the term *hearing impairment* as a generic term when referring to the sample studied. A more comprehensive definition and explanation of *hearing impairment* follows in chapter two.

1.6.2 Movement

On a neurophysiological level, body *movement* occurs when muscles contract across joints (Kolb & Whishaw, 2009:242; Marieb, 2003:176), which are controlled by the motor

cortex, the brainstem and neural circuits in the spinal cord (Kolb & Whishaw, 2009:243). *Movement* as a sensory-motor event leads to brain activation and integration, and plays an important role in the learning process (Hannaford, 2005:107-108). In this report the researcher uses the term *movements* to refer to the selected activities that formed part of the neurodevelopmental movement programme. A comprehensive definition and explanation follows in chapter four.

1.6.3 Neurodevelopmental Movement Programme

This generally refers to a therapeutic programme based on specific activities (usually movement based) to address neurodevelopmental delays (Fredericks *et al*., 2006). For the purpose of the study, the selection and combination of the movement-based activities as a whole is referred to as a *neurodevelopmental programme*. A comprehensive elaboration follows in chapter four.

1.6.4 Neuroplasticity

Neuroplasticity refers to the ability of brain neurons to change their synaptic connectivity when stimulated. Changes in neural networks may allow for improvement in functional abilities (Buccino, Solodkin & Small, 2006; Kolb & Whishaw, 2009:686; Nass, 2002:29). This neuroscientific term is used in this study to understand and explain why changes occurred in a child's developmental profile after taking part in a neurodevelopmental movement programme.

1.7 ETHICAL ASPECTS

As this study occurs within a social context the researcher needed to consider ethical guidelines in designing and executing this study. Babbie (2008:67) advises that everyone that becomes involved in social scientific research should be aware of the agreements shared amongst researchers about what is appropriate and suitable behaviour in scientific inquiry. The following section elaborates on the ethical considerations in this study.

1.7.1 Avoiding Harm to the Learners

The researcher needs to take into consideration the possibility of any physical or emotional harm that subjects might experience during the course of the study. Strydom (2005b:58) adds that subjects should furthermore be informed about the potential impact of the research and then be allowed to withdraw if they so choose.

In this study, the researcher is not aware of any physical or emotional harm that was done to any of the participating learners. The information gathered through the school's records and via the biographical questionnaire completed by the parents did not require sensitive or private information. The activities chosen for the movement programme were not dangerous and learners could not injure themselves or others during the programme. The researcher aimed throughout to be responsive and prepared to act in the best interest of the learners. All movements were done under the watchful eye and with the help of either the researcher or the trained occupational therapist. The researcher monitored this process closely and attended at least three times weekly to implement the programme herself. The programme did not take up long periods of time and the teachers were comfortably able to complete the day-to-day curriculum with all the learners.

1.7.2 Informed Consent and Voluntary Participation

It is of foremost importance that subjects give consent before the research commences. Consent, however, needs to be informed, implying that the researcher divulges all necessary information on the goal of the investigation, the procedures, the possible advantages and disadvantages, any dangerous elements involved in the research, as well as the credibility of the researcher (Strydom, 2005b:59). No participant may be forced to take part in the research study (Babbie, 2008:67).

The Research Committee of the Huguenot College granted approval for the study, after which written permission was obtained from the school's principal. The principal clarified the nature of the study with the school's teaching staff and therapists, and the reaction was overwhelmingly positive. The necessary approval was also obtained from the

Education Department of the Free State (Addendums E and F).

An in-depth information session was held with the therapists and teachers at the school and ample time was allowed to address questions and concerns. This process was vital in this study, as the commitment and enthusiasm of the teachers and therapists played a significant role in the correct implementation of the movement programme, and so impacted on the results of the study. Although the researcher oversaw the correct implementation of the prescribed movements, a trained occupational therapist was responsible for implementing the programme during the days when the researcher did not visit the school.

As the participants of this study were minors, informed consent was obtained from each child's primary caregiver or parent. Parents received a consent form and biographical questionnaire (Addendums A and B) requesting permission for the selected children to be included in the study. The biographical information of each child was drawn from existing school data and information (e.g. birth dates, the severity of the hearing impairment, and medical and educational history) checked for exclusion criteria. No children were excluded based on the biographical information. As some parents were illiterate, the researcher made sure that parents understood the contents of the consent form. This was done by meeting with parents whenever they visited with their children at the boarding facilities on the school premises. It was, however, not possible to meet with all the parents of the sample, as many parents lived far away and children used public transport to commute to school. In such cases consent forms were then either posted to parents or given to hostel parents to discuss with parents when they saw them during weekends. Written consent was then obtained. Parents were informed that they could withdraw their children at any stage and care was taken to explain the consent form thoroughly. Additionally, each child's consent to participate was sought using sign language. All the children were very keen to participate in the study.

1.7.3 Deception of the Learners

Deception refers to the withholding of information or the offering of incorrect information

in an attempt to ensure that subjects consent to participate. Deception therefore compromises the ability of an individual to make an informed decision about participation in a research project (Fischer, 2003:163). Babbie (2008:72) argues that deceiving people is unethical and needs to be justified to great lengths when done so for scientific or administrative reasons. There was no scientific or administrative reason to withhold any information from any party in this study. The study goals and research procedure were explained to the consenting parents and the school.

1.7.4 Violation of Privacy and Confidentiality

Strydom (2005b:61) states that privacy refers to a person's right to personal privacy, while confidentiality has implications for the handling of information. It is important to protect the identity of the children and their families (Babbie, 2008:71). The researcher did not disclose the personal details or identity of the participants in the report and all documentation gathered during the study was treated as confidential and safeguarded from the public. For this reason, each participant was allocated a number in ascending order, from one to eighteen.

1.7.5 Actions and Competence of the Researcher

Researchers should always ensure that they are not only competent when undertaking research investigations, but also adequately skilled in doing so (Fischer, 2003:54; Strydom, 2005b:63). For this study, the researcher had the ongoing support and guidance from two competent researchers and psychologists, who acted as the promoters. The researcher also frequently questioned herself with regard to possible ethical dilemmas that might occur and felt assured that she was competently skilled to undertake this research study.

1.7.6 Release of the findings

The results of a research project must be presented in written form for public use so that it is not only representative as research, but also contributes to the research literature (Strydom, 2005b:65). The researcher reported the final results of the study in a concise, truthful and clear manner.

1.8 CONTEXTUALISATION OF THE STUDY

The research report comprises the following chapters:

CHAPTER 1	INTRODUCTION AND OVERVIEW OF STUDY This chapter gives the problem statement, the motivation for research and a brief outline of the research methodology. Attention is also given to the goal, objectives, hypotheses and key terminology definitions. The chapter concludes with the relevant ethical considerations.
CHAPTER 2	THE AUDITORY SYSTEM AND HEARING IMPAIRMENT As a clinical backdrop to the problem under investigation, this chapter provides a description of the structure of the ear, the auditory system, and the process of hearing. Hearing impairment and related concepts are defined, followed by a section on the prevalence, classification, causes, and possible amplification methods available to children with a hearing impairment. Special attention is also given to the methods of communication and education for the child with hearing loss.
CHAPTER 3	CHILD AND NEURODEVELOPMENT This chapter reviews the research literature on child development and developmental delays. Normal child developmental milestones are discussed from the neural, locomotor, personal-social, cognitive, and language perspectives. Neurodevelopmental delays are introduced in view of aberrant reflexes and their contribution to growth and development.
CHAPTER 4	THE NEURODEVELOPMENTAL BASIS OF HUMAN MOVEMENT AND MOVEMENT INTERVENTIONS The development of movement programmes as an intervention is discussed in view of underlying sensory-motor aspects and their development and contributions to children's growth and development. The interactions between and modulations of these systems are also explained. Developmental movements as a form of neurodevelopmental intervention are a core focus of this chapter.

CHAPTER 5	RESEARCH METHODOLOGY: THE EMPIRICAL INVESTIGATION This chapter reviews the research problem and states specific goals and objectives. An in-depth discussion follows on the research methods, namely, the design, sample composition, and measures used. The chapter concludes with a systematic outline of the data collection procedure and a description on the movement programme.
CHAPTER 6	RESEARCH RESULTS AND INTERPRETATION Chapter six comprises a comprehensive discussion of the findings, with a specific focus on the analysis and statistical results. A report of the results in the form of a neurodevelopmental profile of this specific sample is also presented.
CHAPTER 7	CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS Here the conclusions and limitations of the study are discussed. Recommendations regarding movement programmes for the child with hearing loss are made, together with suggestions for possible future research.

1.9 CONCLUSION

This chapter introduced the research study and presented the contextual background and content of the study. The motivation for the study, together with the goal, objectives and hypotheses were stated. This was followed by a brief overview of the research methods employed. Chapter one concluded with the definition of key terminology and concepts, ethical considerations and an outline of the research study. The following chapter examines the auditory system and hearing impairment.

CHAPTER TWO

THE AUDITORY SYSTEM AND HEARING IMPAIRMENT

"Only by understanding those differences (referring to differences in learning amongst deaf children), can we hope to tailor experiential and educational settings to optimise learning."

(Marschark & Spencer, 2003:494)

2.1 INTRODUCTION AND CHAPTER PREVIEW

Chapter two discusses the auditory system and hearing impairment as a clinical backdrop to the research study. We focus firstly on the structure of the ear and the auditory system, and the development and process of hearing. Second, we examine the definition, prevalence, classification and amplification methods of hearing impairment and, thirdly, the methods of communication and education of the hearing impaired, as well as the impact of hearing impairment.

The effectiveness of the neurodevelopmental movement programme is largely dependent on the correct selection of activities and movements. The aim of this chapter is therefore to examine the auditory system and hearing impairment to provide a theoretical background for understanding the effect of hearing loss. From there, relevant activities and movements can be selected for the neurodevelopmental movement programme of this study.

2.2 THE STRUCTURE OF THE EAR AND THE AUDITORY SYSTEM

The auditory system is a mechanical system that decodes acoustic energy into sound. It does this by passing sound waves down through the ear until specialised cells are able to translate the sound into a code that is interpretable by and comprehensible to the brain. The ear is divided into three parts: the external, middle and the internal ear (Bear, Connors & Paradiso, 2007:348; Bhise & Yadav, 2008:12.2).

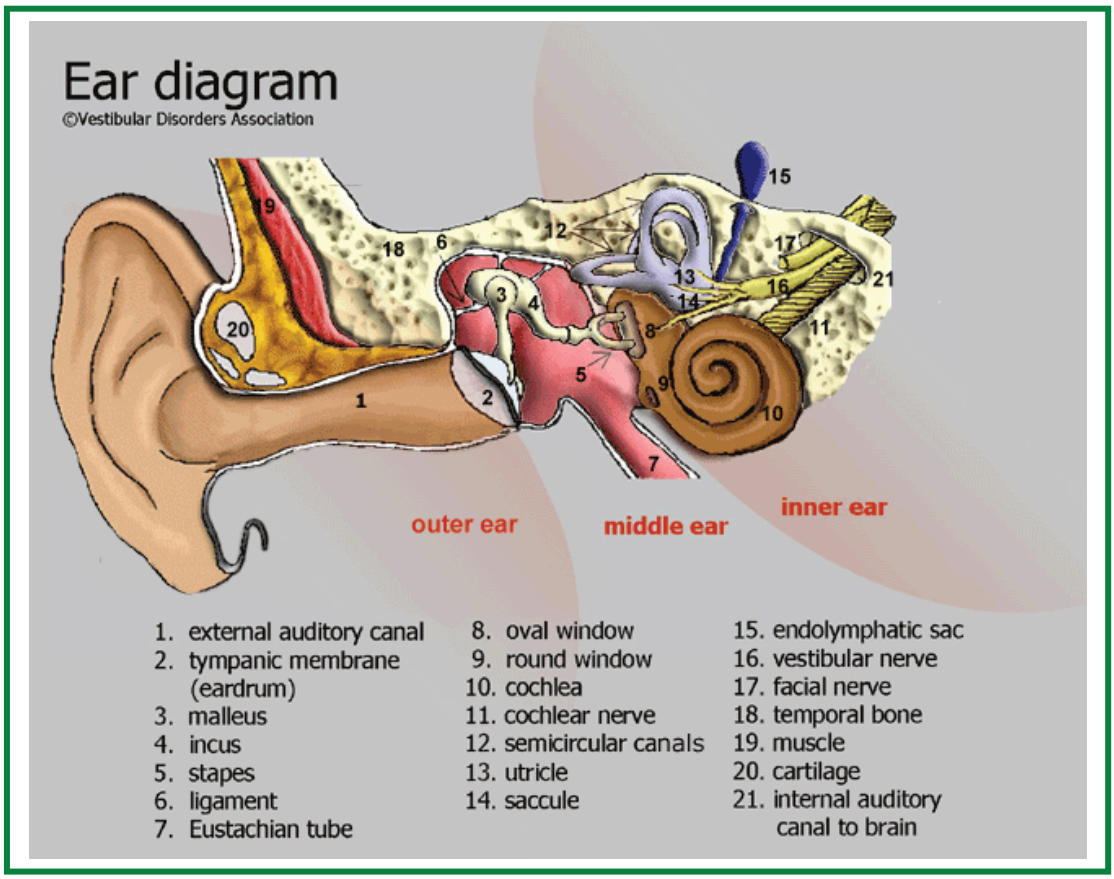

Figure 2.1 Anatomy of the Ear

(Vestibular Disorders Association, 2010)

As shown in figure 2.1, the first structure in the auditory system is the *external or outer ear*. The pinna is the part of the ear that can be seen and serves to funnel sound into the ear down the auditory canal to the middle ear. The pinna is composed of mainly cartilage and fat deposits and its function is to determine the location of sound (Hakala, 2009:61). The purpose of the auditory canal is to focus all the sound waves toward the tympanic membrane (the eardrum). This membrane, which is a thin tissue stretched out over a bone, will vibrate when sound waves beat against it and transmits the waves to the middle ear (Hakala, 2009:62; Sherwood, 2010:216; Vera-Portocarrero, 2007:24).

The structures within the *middle ear* are the tympanic membrane, the ossicles, and two tiny muscles attaching to the ossicles. The tympanic membrane is fairly conical in shape, with the point of the cone extending into the cavity of the middle ear (Bear *et al*.,

2007:348). The Eustachian tube runs from the middle ear into the nasal cavity and ensures an equal degree of atmospheric pressure on both sides of the tympanic membrane. This is necessary to preserve the eardrum's sensitivity to sound waves, as the drum loses some of its vibratory capacity in different atmospheric pressures (Bhise & Yadav, 2008:12.2; Sherwood, 2010:217).

The vibrations of the tympanic membrane are carried further into the ear via the three smallest bones (ossicles) in the human body. These small bones are known as the malleus (hammer), incus (anvil) and stapes (stirrup). The ossicles are arranged across the middle ear like a chain lying between the tympanic membrane and the inner ear. The stapes is attached to the oval window. The flat bottom portion of the stapes (the footplate) moves in and out like a piston at the oval window. These three bones will then in return vibrate to the sound waves that are causing the tympanic membrane to vibrate (Hakala, 2009:62), and transmit the sound from the tympanic membrane to the fluids of the cochlea in the internal ear (Bear *et al*., 2007:349; Bhise & Yadav, 2008:12.2; Kolb & Whishaw, 2009:210; Vera-Portocarrero, 2007:25).

The two tiny muscles attached to the ossicles have a major effect on the transmission of sound to the inner ear. When these muscles contract, the chain of ossicles becomes much more rigid, the tympanic membrane tightens, and sound conduction to the inner ear is greatly diminished. The onset of a loud sound will cause these muscles to contract via a triggered neural response. This neural response is referred to as the attenuation reflex, and has the goal of protecting the inner ear from very loud noises. The attenuation reflex has a delay of 40 to 100 milliseconds from the time that sound reaches the ear, so unfortunately it does not offer much protection from very sudden loud sounds. Damage to the cochlea might already be done by the time the muscles contract. That is why, despite the rather amazing abilities of the two tiny muscles and the best efforts of the attenuation reflex, a loud and sudden explosion can still damage the cochlea (Bear *et al*., 2007:350; Sherwood, 2010:217).

The *inner or internal ear,* where the auditory receptors are to be found, is filled with fluid and made up of the cochlea, utricle, the saccule and the three semicircular canals.

While the cochlea is considered the main sensory organ for hearing, the other parts provide important information for balance (Bhise & Yadav, 2008:12.2). The cochlea has a bony, coiled tube of two-and-a-half turns and has the shape of a snail (see figure 2.1). It is fluid-filled and the basilar membrane floats in this fluid, in the middle of the cochlea. The vibrating stapes presses against the fluid in the cochlea and causes waves to flow through the fluid, which in return causes the basilar membrane to vibrate. On the basilar membrane are receptor cells (hair cells), which are embedded in a part of the basilar membrane, called the organ of corti. The axons of the hair cells leave the cochlea to form the major part of the auditory nerve, the eighth cranial nerve (Kolb & Whishaw, 2009:211-112). The 15 000 hair cells within each cochlea are arranged in four parallel rows. Hair cells make contact at their base with fibres from the auditory nerve, and have a bundle of about 100 hairs projecting upwards (Sherwood, 2010:217). The vibrations of the basilar membrane stimulate the hair cells. These patterns of stimulation are then transmitted along the basilar membrane along the auditory nerve, to the auditory cortex (in the temporal lobes of the brain) (Bear *et al*., 2007: 351-352; Hakala, 2009:62; Kolb & Whishaw, 2009:212).

Figure 2.2 shows schematically the auditory pathway where auditory signals are processed in the brain. As explained, the sense of hearing starts when the middle ear converts sounds, or vibrations in the air, into signals that travel along the cochlear nerve. On reaching the brain, that information is sent through a series of nuclei in the brain stem to the auditory cortex (Dana Foundation, 2007).

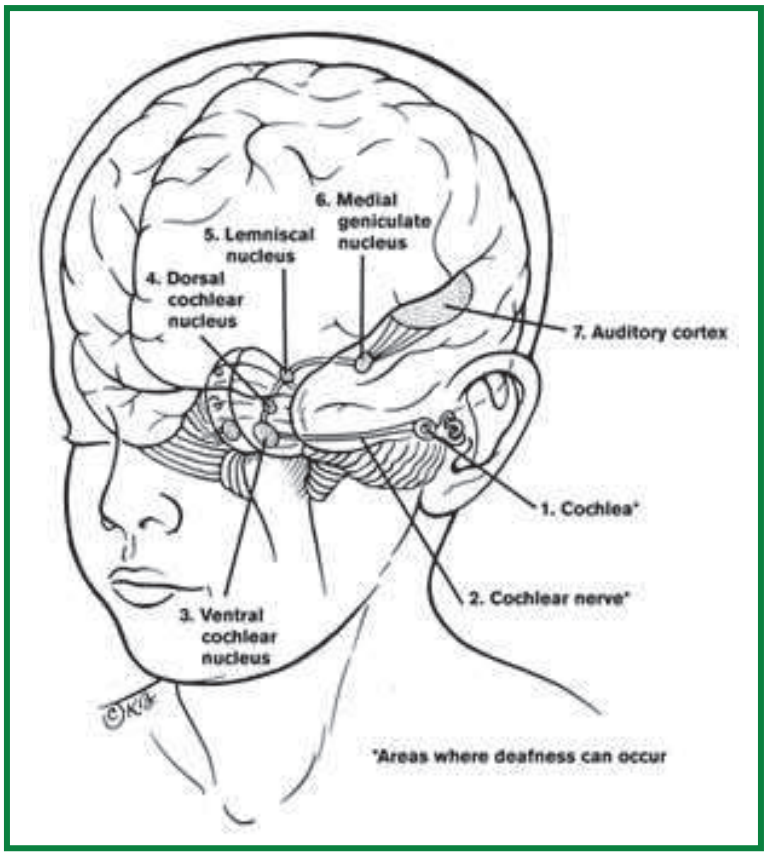

Figure 2.2 Auditory pathways

(Dana Foundation, 2007)

The three semi-circular canals (see figure 2.1) are referred to as superior, posterior and lateral. A swelling on one end of each semicircular canal, called the ampulla, assists the cerebellum in the control of equilibrium and the sense of position of the body (Bhise & Yadav, 2008:12.2). These three canals form part of the vestibular system, which is discussed in detail in chapter four.

The development of the auditory system is a complex and multistage process that begins in early embryonic life (Schnupp, Nelken & King, 2011:270). According to Northern and Downs (2002:38), the first signs of the ear are seen early in the third week in the human embryo. A cellular ectodermal thickening emerges at the cranial end of the embryo and will thicken to develop into the membranous labyrinth. The cartilage gives rise to the ossicles during the fourth week of gestation, whilst the external ear and external auditory canal develop between the fourth and sixth week (Northern & Downs,

2002:42). As the ossicles develop, the central nervous system connections are established to the cochlea and the vestibular structures (Goddard, 2005:64). By approximately eight weeks the incus and the malleus have attained a complete form similar to that of an adult and will have nearly reached completion by the 32nd week of gestation. The stapes begins to ossify (harden) around the 18th week of gestation and continues to develop through life, even after ossification is complete (Northern & Downs, 2002:42). During the eighth through eleventh week, the coils of the cochlea and the fluid-filled space are forming. During these early weeks, development of the inner ear is paralleled by development of the cochlear nerve, which will ultimately transmit cochlear activity to the central auditory system (Moore & Linthicum, 2007).

Complete maturation of the sensory and supporting cells inside the cochlea does not occur until the fifth month, when it will show considerable growth and expansion. The inner ear is the only sense organ to reach full adult size and differentiation by foetal midterm (Northern & Downs, 2002:40). In the 20th week the external ear has an adult shape, but continues to grow in size until the individual is nine years old (Northern & Downs, 2002:42). By week 22, the process of myelination (the insulating of nerves with a fatty substance; this process is discussion further in later chapters) has begun within the cochlea (Moore & Linthicum, 2007). Myelination of the auditory nerve and the major brainstem pathways occurs between the 24th and the 28th week in utero. Sound perception develops slowly from this time onward (Goddard, 2005:64). It is also around this time that the first responses to sounds can be measured (Schnupp, Nelken & King, 2011:271). Given the appearance of myelin at the beginning of the third trimester from the cochlear outlet through the brainstem and up to the auditory thalamus, it is not surprising that these behavioural and physiological responses to sounds are noticed (Moore & Linthicum, 2007). From the 24th week of pregnancy, foetuses can hear a restricted range of lower to medium frequency sounds, which roughly correspond to the range of the human voice and the majority of musical instruments used in classical music. All sounds heard inside the womb are reduced in volume by about 30%, the loudest sound being that of the mother's heartbeat (Goddard Blythe, 2004:201; Goddard, 2011:38).

Although the beginnings and major changes to the auditory system take place in utero, the development does not conclude, nor is it totally complete, at the time of birth. There appear to be three successive stages of auditory development in humans. Moore and Linthicum (2007) summarise the first phase as the three months of the second trimester where myelination occurs only in the intra-cochlear portion of the cochlear nerve, and when the cochlea reaches virtually full maturation. In the second phase, the perinatal period (third trimester to the sixth postnatal month), myelination of the brainstem pathway occurs from the cochlear nerve to the thalamus. The third phase of development, which includes progressive myelination of the auditory cortex, is a decade-long course lasting through early and later childhood.

Infancy and childhood are times of major change in auditory processing, most notably the acquisition of receptive speech (Moore & Linthicum, 2007). During the first three years of life, children learn to use their ears to “tune in” to the specific frequencies of their own language. Goddard (2005:65) explains this as much the same way that a radio is adjusted to select specific stations. It is also during this time that children have the potential to learn any language if exposed to the sounds of that language continuously over a period of time. It becomes far more difficult to assimilate a new language after the age of three years, when these fine tuning adjustments should have already been made.

2.3 DEVELOPMENT AND PROCESS OF HEARING

Hearing involves the gathering and interpretation of sounds. It is the ability to construct perceptual representations from pressure waves in the air, in order to generate meaningful information for the brain. The auditory system is complex both because (a) many transformations of pressure waves take place through the outer, middle and the inner ear before action potentials are generated in the auditory nerve; and (b) the auditory nerve projects to many targets in the brainstem and areas of the cortex in the temporal lobe where the action potentials are then interpreted as sounds, language, and music (Kolb & Whishaw, 2009:209). The first of these two processes were discussed in the previous section, while this section concentrates on the latter. It would be difficult to

explain how the brain makes sense from sounds without first understanding the concept of sound.

2.3.1 The Mechanism of Sound

Alternating regions of compression and rarefaction of air molecules form sound waves (Sherwood, 2010:215). Sounds are therefore changes in air pressure waves within a specified range of frequencies and intensities. The **frequency**, **amplitude**, and **complexity** of these changes determine what individuals hear (Kolb & Whishaw, 2009:209). When someone suffers from a hearing impairment, therefore, the perception of one or all of these features is affected (Schröder, 2004:15).

The frequency or speed of pressure changes is heard as changes in pitch, whereas loudness is determined by the amplitude or intensity of pressure changes. People hear the complexity of pressure changes as tone (timbre), or the perceived uniqueness of a sound. These differences in air pressure are detected by receptor cells in the inner ear and are then transferred from there to the brain. Areas of the cortex in the temporal lobe deduce this information as sounds, language, and music. Organisation of the patterns of human speech contributes to the development of language (Cheatum & Hammond, 2000:313; Kolb & Whishaw, 2009:209).

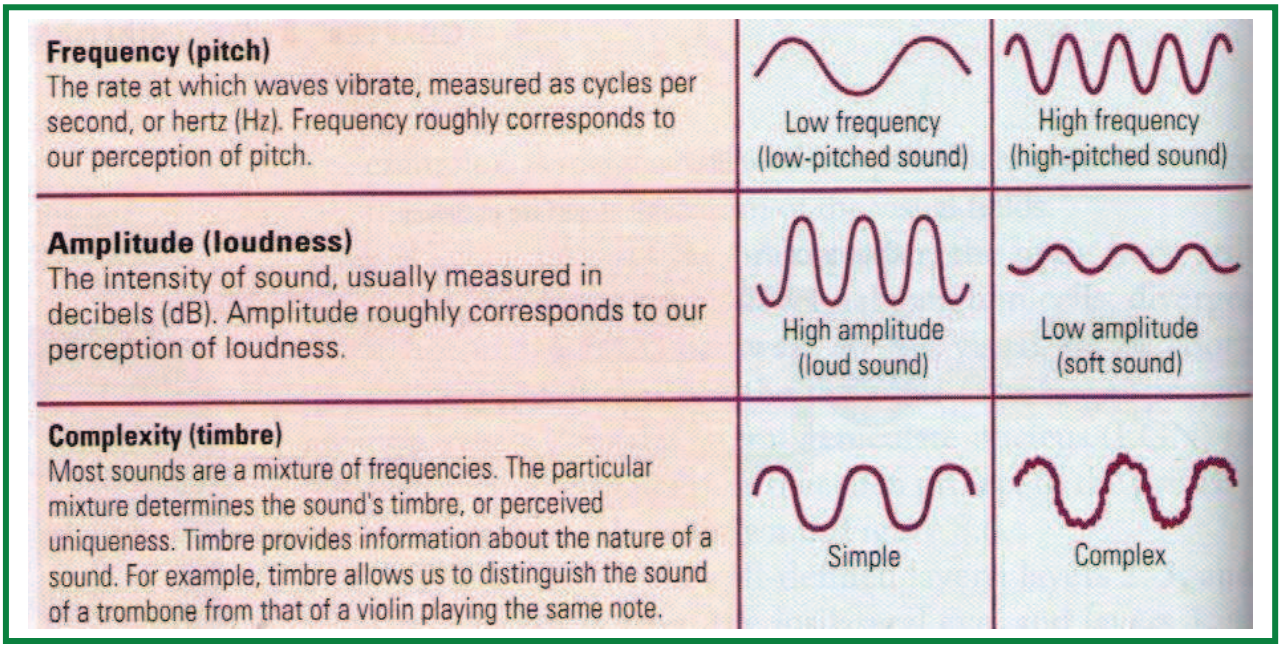

Figure 2.3 Breaking Down Sound

Sound waves have three physical dimensions that correspond to the perceptual dimensions of pitch, loudness, and timbre (Kolb & Whishaw, 2009:210; Sherwood, 2010:216).

Figure 2.3 is a graphical presentation on each of the three constructs of sound, namely frequency, amplitude and complexity. A more comprehensive explanation of these constructs follows.

2.3.1.1 Frequency

Frequency refers to the number of sound vibrations that occur in a single second. The greater the frequency (the faster the vibration), the higher the pitch of the sound produced (Cheatum & Hammond, 2000:311; Sherwood, 2010:214). The human ear is capable of perceiving sound waves between 20 and 20 000 hertz (Hz, cycles per second). Most speech is in the range of 200 Hz to 6000 Hz, and is a mixture of these frequencies (Kolb & Whishaw, 2009:199; Sherwood, 2010:214; Snyder, 2000:27-28). It is suggested that newborns are very sensitive to sounds that occur within the typical frequency of a human voice, while being less sensitive to low-pitched sounds (Keenan & Evans, 2009:141; Madell & Flexer, 2008:59). From these findings it is apparent that human hearing is designed to receive the most vital element of communication, namely, speech. Every language has its unique frequency band, within which fall all the sounds

used in that language. As mentioned, key stages for learning language are well known, and if key stages are missed, the chances of subsequently developing skills in that area are considerably reduced. This happens because the child learns to filter out unnecessary sounds (Goddard, 2005:67). As infants "tune in" to the sounds of their mother tongue, discrimination within a very specific band of frequencies improves at the expense of those frequencies that are not required. If a child needs to learn a new language at a later age, the neurons (basic structure of brain cells) that might have become dedicated for that language may have become specialised for a different function or might simply have been discarded as redundant. New languages can be learned, but accent and fluency will never be acquired with such absolute ease as during the first three years of a child's life (Goddard, 2004:23).

2.3.1.2 Intensity

The concept "*loudness*" is subjective and therefore difficult to measure, so the intensity of sound is measured instead. The intensity of sound is measured in decibels (dB). A decibel refers to the measure of the loudness of the sound. The sound will therefore be louder when the amplitude is greater. The human ear is most sensitive to intensities between 0 and 100 dB (Sherwood, 2010:214). Prolonged or repeated exposure to sounds above 100 dB may cause permanent structural damage to the hair cells in the cochlea (Bhatnagar, 2002:196; Sherwood, 2010:214). Keenan and Evans (2009:141) report that a sound must be approximately 10 to 17 decibels louder for an infant to hear it than for an adult.

2.3.1.3 Complexity

The timbre of sounds depends on its overtones, which are additional frequencies superimposed on the fundamental pitch or tone. Overtones are likewise responsible for characteristic differences in sounds (Sherwood, 2010:214-216). The timbre makes it possible, for instance, to distinguish between different people's voices.

These three features of sound make it possible for hearing to be assessed and hearing loss to be identified. This is typically done via a hearing assessment, with results

generally being presented on a graph known as an audiogram (Martin & Clark, 2000:84).

2.3.2 The Audiogram and Hearing Assessment

One of the objectives of testing hearing is to determine which frequencies the ear is able to respond to. The test measures the intensity a sound must reach before the ear can become aware of it. Audiologists keep track of exactly which tones each ear hears, and most use a standard graph called the audiogram (Martin & Clark, 2000:84,112). This graph is a visual picture of what the ear hears (see figure 2.4).

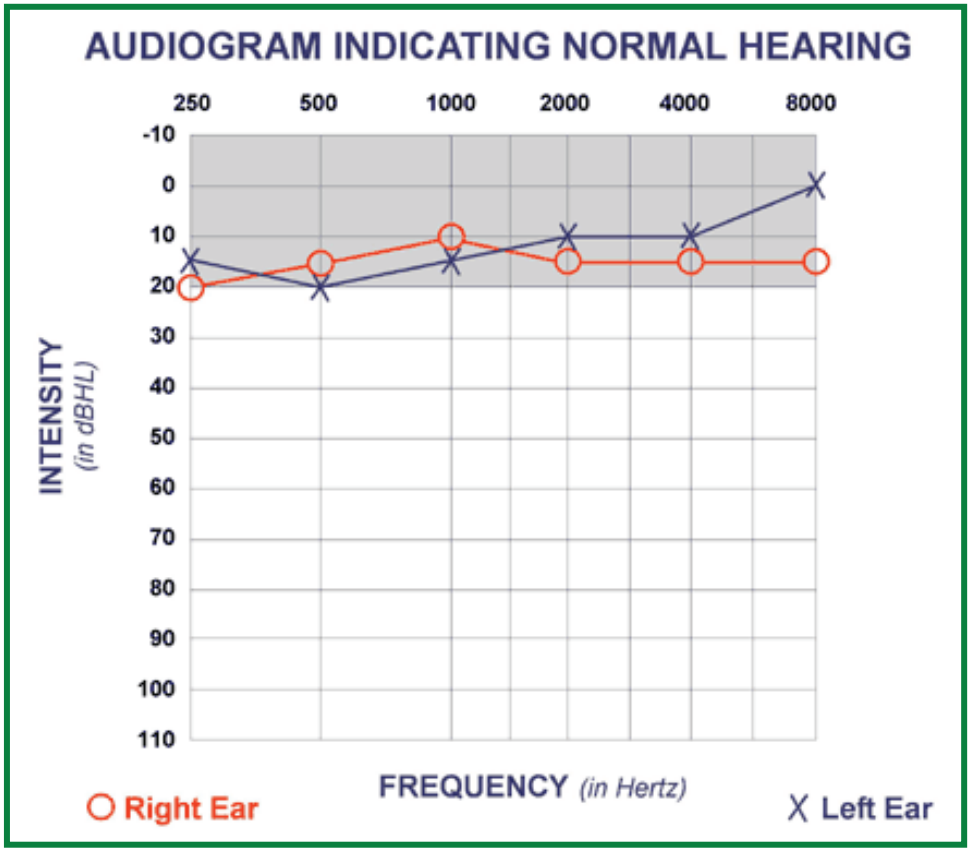

Figure 2.4 Normal Hearing

(Hearing Life, 2010)

The vertical lines symbolise frequency or pitch. The vertical line on the left side of the audiogram represents a very low pitch sound and each vertical line to the right represents a higher pitch sound. Moving from left to right on the audiogram would be consistent with moving from left to right on a piano keyboard. The horizontal lines

represent loudness or intensity. The 0 dB line near the top of the graph symbolises an extremely soft sound. Each horizontal line below represents a louder sound. Moving from the top to the bottom of the graph would be consistent with hitting the piano key progressively harder (Roeser & Downs, 2004:37).

A hearing test therefore involves finding the threshold for hearing pure tone sounds at a number of different frequencies across the range that is important for speech understanding. Patients will typically click a button when they hear a tone. The point at which the sound is just detected is called the “threshold” (the softest sounds a person can hear). People with normal hearing have thresholds of around 0 to 25 dB for all frequencies. Graphed results display the individual’s hearing thresholds, and are marked on a chart using a circle for the right ear and a cross for the left ear. Colours are optional, but usually red denotes the right ear and blue the left ear. The results are then joined by a line (Hearing Life, 2010; Maltby, 2005:129; Schröder, 2004:16). By comparing the values on the graph, the audiologist can assess the respective degree of hearing loss and find clues as to its origin.

Sounds can be heard through two basic physiological pathways: the traditional *air conduction* route, or the *bone conduction* pathway. The traditional air conduction route has been discussed in detail in the preceding section of this chapter. According to Northern and Downs (2002:50-51), humans can also hear sounds by a bone conduction pathway that bypasses the external and middle ears. Bone-conducting sounds stimulate the inner ear, in much the same way as air-conducting sounds that enter through the external ear. This is done by mechanical vibrations from the bones of the skull. Because the inner ear is enclosed within the bones of the skull, vibrations carried through the mandible; jaw and throat cause the fluids to move within the inner ear (Northern & Downs, 2002:5). Whether the activity is stimulated by air conduction or bone transmissions of the vibrations, the perception of sound in the brain is exactly the same. By comparing air-conducting and bone-conducting sounds during an audiology assessment, audiologists can determine the type and location of a hearing problem (Northern & Downs, 2002:6). This distinction is made by using a bone vibrator that

bypasses the mechanical parts of the middle ear. If hearing is better using bone than air then a conductive hearing loss is suspected (Hearing Life, 2010). The different types of hearing loss are explained more comprehensively in the following sections.

Figure 2.5 represents a picture-audiogram, which indicates the frequency and intensity of general English sounds, compared with ordinary environmental sounds. According to Schröder (2004:18), similar picture-audiograms are used in South Africa to explain hearing loss and its effects to parents of children with hearing impairment.

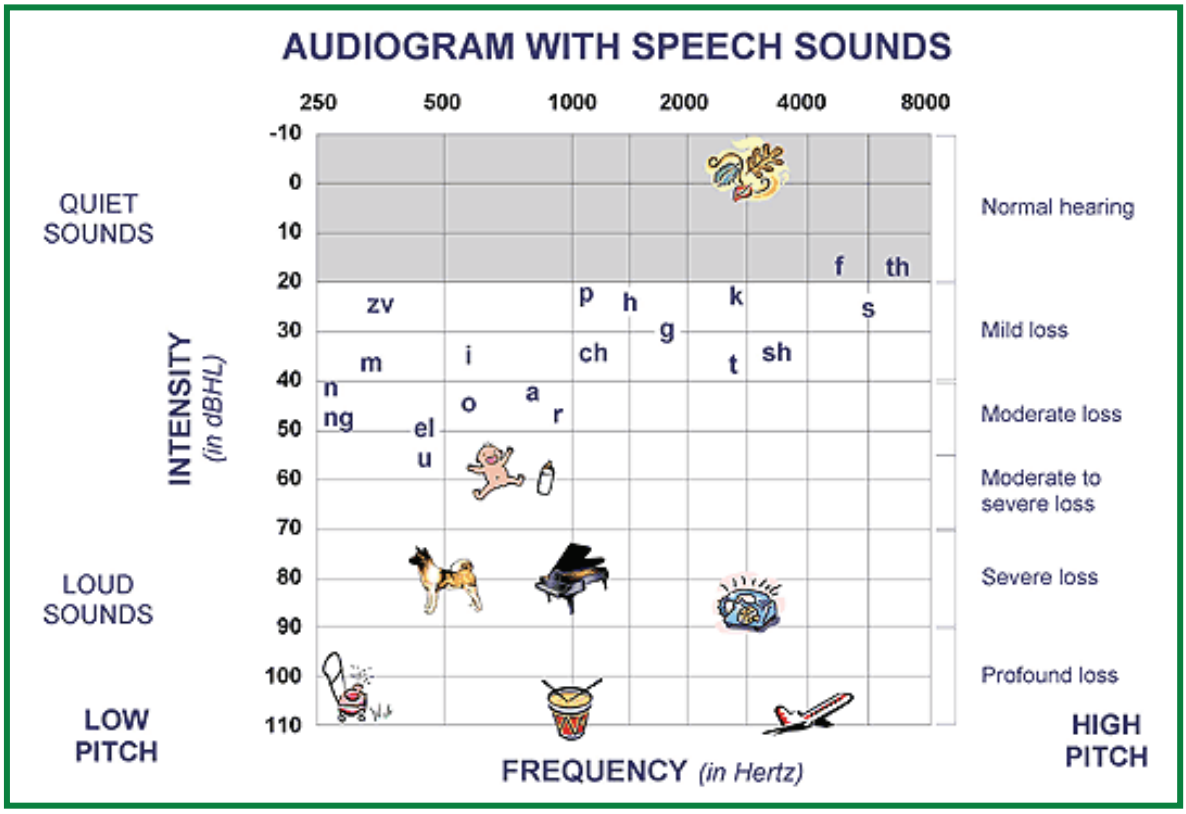

Figure 2.5 Audiogram with Speech - and Ordinary Sounds

(Hearing Professionals, 2010)

Similar sounds in the English language, such as "*s*" and "*f*", "*f*" and "*th*", "*th*" and "*sh*" are high-frequency sounds. Sounds like "*p*" and "*b*", "*b*" and "*d*", "*m*" and "*n*" are all middle and low frequency sounds. If a child lacks the ability to detect the difference between different sound frequencies and specific sounds (which is referred to as auditory discrimination) the rules of spelling (in English) have little relevance. Similarly, sounds in

the English language are hard to distinguish if there is any high frequency hearing loss (Goddard, 2005:68; 2009:346). The range of difference between a medical diagnosis of hearing loss and the hearing acuity required to detect and use the sounds of language can easily be as wide as 40 decibels at certain frequencies (see figure 2.5). Goddard (2009:327) explains that children can pass standard hearing tests, but may still lack the acuity needed for discriminating between different sounds; and as a result will then struggle to use the sounds of written language with accuracy and fluency. The brain's ability to hear the fine-tuned differences can be impaired, particularly to sounds in the higher frequencies such as "*s*" and "*f*", as well as "*sh*" and "*ch*". Auditory discrimination problems could be a result of frequent or prolonged periods of intermittent deafness resulting from congestion or ear infections. Hearing can be impaired for up to eight weeks after the acute period of infection has cleared up (Goddard, 2009:228).

As the focus of this study centres on the child with a hearing disability, it is important not only define the term, but also to understand the prevalence of this disability in the world and in South Africa. The following two sections will focus on these topics in turn.

2.4 DISABILITY AND IMPAIRMENT

Approximately 650 million people worldwide live with some form of disability or impairment (World Health Organisation, 2010a), constituting about 10% of the world's population. It is estimated that about 80% of people with disabilities live in developing countries, such as South Africa, where resources are often insufficient to meet their rehabilitation and basic healthcare needs (World Health Organisation, 2010b). A 2001 South African census estimated that people with disabilities constituted 5% of the country's population, with the Free State being the province with the highest prevalence of 6.8% (Statistics South Africa, 2005:11-12).

Disability, handicap and impairment are complex terms, with an abundance of definitions, professional opinions and theoretical arguments on their meaning (Read, Clements & Ruebain, 2006:205; Simeonsson, Lollar, Hollowell & Adams, 2000). This debate continues; but to ensure an orderly approach to the subject, this study adopted the definitions provided by the International Classification of Impairments, Disabilities

and Handicaps (Simeonsson *et al*., 2000). These definitions are as follows:

- *Disability:* "reductions of a person's ability to perform basic tasks" (Simeonsson *et al.,* 2000:114), which are "characterized by excesses or deficiencies of customarily expected activity, performance and behaviour" (Simeonsson *et al*., 2000:119).
- *Impairment:* "abnormalities of body or organ structures or functions" and "any loss or abnormality of psychological, physiological, or anatomical structure or function" (Simeonsson *et al*., 2000:114).
- *Handicap:* "a person's experienced disadvantage to fulfil social roles"; "disadvantage experience in major survival roles," and "experienced disadvantage in doing things independently" (Simeonsson *et al*., 2000:114).

The term *disability* is used as an umbrella term in this study to encapsulate different kinds of disabilities, with the term *impairment* referring specifically to a hearing impairment.

2.4.1 Hearing impairment

In the present study, the focus was on a certain category of disability, namely hearing impairment. The definition of general hearing impairment is specified in terms of the categories of deafness and forms the focus of this section.

Through the literature review it became clear that there are several terms to describe individuals with hearing loss, and that definitions of these individual terms vary according to theory and practice. It would appear that normally the terms *deaf*, *Deaf* and *hard-of-hearing* are used to refer to individuals who have some kind of hearing impairment or auditory disability.

- According to the Concise Oxford Dictionary, the term *deaf* refers to individuals who are wholly or partly unable to hear (Allen, 1990:296).
- Deaf people all over the world view themselves as belonging to a linguistic

minority with its own language, history, shared values, culture and community. As such, the proper noun "*Deaf*" (spelled with a capital "D") refers to this particular group of people (Deaf Federation of South Africa, 2009a).

- Northern and Downs (2002:11) suggest that the term *hard-of-hearing* describes hearing losses in the mild, moderate and severe categories. This would therefore refer to a hearing loss that makes it difficult, but not necessarily impossible, to understand speech solely through the ear. The National Institute for the Deaf (2009) uses the term *hard-of-hearing* to refer to people with some hearing ability, ranging from those with the ability to hear environmental sounds to those who use a hearing aid.

The definitions and classification for the term *hearing impairment* also differ according to the purposes for which they were developed, such as medical, educational or psychological. Usually a hearing impairment is described by a measure of the severity of the hearing loss, and the type of pathology present (Northern & Downs, 2002:10). The following classification system relates to children (see table 2.1). In this study, the term hearing impairment is used as a generic term to refer to all levels of hearing loss.

Table 2.1 Guidelines Used to Describe Degrees of Hearing Impairment in Children

(Northern & Downs, 2002:21; Roeser & Downs, 2004:43)

Average hearing level (500 – 2000 Hz) Hearing threshold level	Grade of impairment Degree of hearing loss	What can be heard without amplification
0 – 15 dB	Normal range	All speech sounds
15 – 25 dB	Slight hearing loss	Vowel sounds heard clearly; may miss unvoiced consonant sounds
25 – 30 dB	Mild hearing loss	Only some of speech sounds, the louder voice sounds
30 – 50 dB	Moderate hearing loss	Almost no speech sounds at normal conversational level
50 – 70 dB	Severe hearing loss	No speech sounds at normal conversational level
70+ dB	Profound hearing loss	No speech or other sounds

Just as the definitions of terms specifically related to hearing impairment differ, so do the thresholds of identifying the degree of hearing loss. Table 2.2 was sourced from the South African Association of Audiologists (2010a) and presents categories of hearing loss according to different decibel thresholds. Cummings (2008:115) argues that 15 dB should be considered the lower limit for children (as opposed to 20dB for adults), as children lack the adult strategies for understanding speech in context and would therefore need to hear all speech sounds in order to create perceptions of these sounds.

Table 2.2 Degree of Hearing Loss

(South African Association of Audiologists, 2010a)

Softest intensity that sound is perceived	Categories of hearing loss
0 – 20 dB	Normal hearing
20 – 40 dB	Mild hearing loss
40 – 55 dB	Moderate hearing loss
56 – 70 dB	Moderate to severe hearing loss
71 – 90 dB	Severe hearing loss
90+ dB	Profound hearing loss

The children in the current study suffered from a severe to profound hearing impairment and used only signing to communicate. It is noteworthy that no two individuals have the same pattern of hearing, even if they fall within the same category. Different factors, such as the age of diagnosis, the educational intervention, other impairments and the child's social-emotional development all influence the impact of the hearing impairment on the child (Archer-Swanepoel, 2010a).

The study sample was therefore heterogeneous in terms of the degree of hearing loss. The degrees of hearing impairment indicated in table 2.2 were used as a guideline to describe the degree of hearing loss in this study, as this is the scale according to which the specific school and most South African audiologists currently function.

2.5 INCIDENCE AND PREVALENCE OF HEARING IMPAIRMENT

The World Health Organisation (2010c; 2012) states that, in 2005, about 278 million people across the world had moderate to profound hearing impairment. Eighty percent of them live in low or middle-income countries. South African statistics on people with hearing impairment is not only outdated (based on a 2001 census), but also somewhat unreliable. Statistical reports from the 2011 South African census were not available at the time of completing this research report and will only be available in March 2013 (Statistics South Africa, 2012). The researcher came across conflicting figures during the literature review (compare, for instance, National Institute for the Deaf, 2009 with Statistics South Africa, 2005).

The National Institute for the Deaf (2009) refers to the figures from the 2001 census in reporting that there are 412 421 people with profound deafness and 1 237 264 extremely hard-of-hearing people in South Africa. According to the Statistics South Africa Census 2001 document (Statistics South Africa, 2005:51), the prevalence of South Africans with a hearing disability was approximately 20.1% (453 104) of the disabled population, which makes it the third highest reported disability. The fact that hearing impairment has a significantly higher prevalence than any other birth defect was noticed and reported already on during the late nineties (Mehl & Thomson, 1998).

Infant hearing loss is the most common congenital sensory birth defect, with a prevalence of four to six babies per 1000 live births in developing countries such as South Africa (Olusanya & Newton, 2007). This is higher than the usually quoted figure of one to three per 1000 births for developed countries (South African Association of Audiologists, 2010b). This association considers (a) that one in 1000 children is born with profound deafness; and (b) that an additional two children in a 1000 will acquire deafness in early childhood. Preliminary reports in South Africa propose that approximately 17 babies are born with or will develop hearing loss in South Africa every day. Of these babies, 85% are born in the public health sector, where medical care is not always well-resourced (Swanepoel, Störbeck & Friedland, 2009).

The study sample consisted of children between four and eight years of age. Statistics South Africa (2005:51) indicated that there were 33 554 children with hearing impairment between the ages of five and nine years. Table 2.3 below gives a breakdown of the people with a hearing impairment in South Africa according to cultural group.

Table 2.3 Percentage of People with a Disability Affected by a Hearing Impairment According to Cultural Group

(Statistics South Africa, 2005:52-55)

Type of disability	White %	African %	Coloured %	Indian/Asian %
Hearing	26.1%	19.7%	18.2%	16.2%

Looking at the Free State Province of South Africa, where the study sample was drawn from the rural area of QwaQwa (Phuthaditjhaba), a total of 185 377 people with disabilities were reported out of a population of 2 706 775. The table below provides a summary of these findings by population group.

Table 2.4 People with Disabilities in the Free State by Population Group

(Statistics South Africa, 2005:43)

Population Group	Total population	With disabilities
Total	2 706 775	185 377
African	2 381 073	167 229
Coloured	83 193	4955
Indian/Asian	3719	103
White	238 791	13 090

In the Free State, 14 286 children between birth and nine years have disabilities (Statistics South Africa, 2005:43). Unfortunately, no breakdown of the nature of these disabilities was available.

The lack of adequate and precise data on people with disabilities may be due to the

different definitions of disability, different survey methods used in collecting the data, less sympathetic attitudes towards people with disabilities, a poor service infrastructure for people with disabilities in underdeveloped areas, and violence levels at particular times, which impeded the collection of data and thus affected the general picture (Statistics South Africa, 2005:6). What is certain is that children with disabilities, especially in rural areas, are often ignored, neglected, and have difficulty in accessing rehabilitation services. As a result, much of their potential as adults goes untapped. This can result in increased poverty and dependence, which can at the very least, negatively influences South Africa's public and financial development (Tshabalala-Msimang, 2007; Archer-Swanepoel, 2010b; World Health Organisation, 2010b).

2.6 CLASSIFICATION OF HEARING LOSS

There are different ways to classify hearing loss. According to Adams and Rohring (2004:17) and Burkey (2006:34-35), the generally accepted way to classify hearing loss is:

- based on the age of *onset* of the hearing loss in relation to the development of language and speech; and/or
- based on the *location* of the loss in the ear; and/or
- based on the *cause* of the hearing loss.

Hearing loss can be unilateral, where loss is only present in one ear (Roeser & Downs, 2004:245), or bilateral, where hearing loss presents in both ears. The degree of hearing loss in each ear will not necessarily be the same and can vary significantly (Schröder, 2004:26). Asymmetrical hearing loss indicates a different degree of loss in each ear, while symmetrical hearing loss occurs when the configuration of the loss is the same in both ears (South African Association of Audiologists, 2010b). The following three subsections provide a comprehensive explanation of the three generally accepted classification methods to hearing loss.

2.6.1 The Age of Onset of the Hearing Loss in Relation to Language and Speech Development

Two constructs are used when describing the age of onset of the hearing loss, namely

prelinguistic or postlinguistic hearing loss. Prelinguistic or congenital hearing loss refers to a hearing condition where the person is born deaf (congenital) or becomes deaf before the normal development of language skills and speech, typically before the age of three. Such a person usually uses sign language as the primary mode of communication (Adams & Rohring, 2004:17; Martin & Clark, 2000:433,446).

Postlinguistic hearing loss refers to a hearing impairment acquired after the acquisition of a spoken language and the formation of language concepts. This happens typically after the age of three (Adams & Rohring, 2004:17; Martin & Clark, 2000:433,446).

2.6.2 The Location of the Loss in the Ear

Various causes of hearing impairment affect different portions of the ear and the hearing mechanisms inside the ear (Schröder, 2004:23). These can be divided into three basic types, which are referred to as conductive, sensorineural or mixed hearing loss (Martin & Clark, 2000:16).

2.6.2.1 Conductive Hearing Loss

Conductive hearing loss is the most common type of hearing impairment found in children and not only often fluctuates, but also frequently goes unnoticed (Bennetts & Flynn, 2002; Northern & Downs, 2002:10). It is caused by interference or obstruction with the passage of sound waves thorough the outer and middle ear. The inner ear is usually capable of normal function, but the sound vibration is unable to stimulate the cochlea via the normal air conduction route (Goddard, 2011:193; Martin & Clark, 2000:16; South African Association of Audiologists, 2010b; World Health Organisation, 2010c).

The sounds can either be blocked or the ear structures can fail to convey the sound waves. Earwax blocking the ear canal or infection in the outer or middle ear (such as chronic middle ear infection or otitis media) can block the sound. Dysfunction or obstruction in the Eustachian tube, damaged ossicles or a torn tympanic membrane can also cause conductive hearing loss by not succeeding to convey sound. Although some

conductive hearing losses resolves spontaneously (Northern & Downs, 2002:10), it is often treatable, either surgically, medically or with hearing aids (South African Association of Audiologists, 2010b; Burkey, 2006:35; World Health Organisation, 2010c).

Hearing loss is usually in the mild to moderate range of hearing impairment (Northern & Downs, 2002:21), and usually leads to a reduction in sound level, or the ability to hear faint sounds (South African Association of Audiologists, 2010b). Sensitivity to sounds introduced by air conduction is impaired by such a hearing loss, whereas sounds introduced by bone conduction can bypass the obstruction or interference and go directly to the sensorineural mechanism (Martin & Clark, 2000:16). As figure 2.6 (Audiogram B) indicates, bone conduction appears to be normal, while air conduction is impaired on all frequencies.

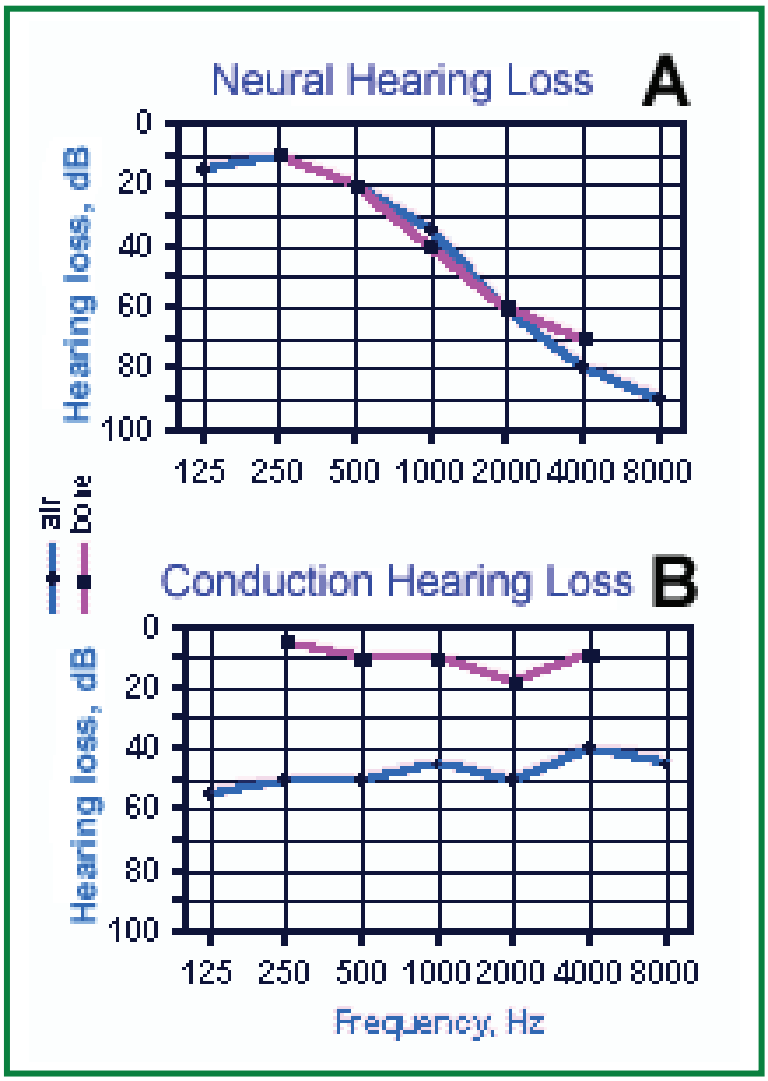

Figure 2.6 Audiogram Indicating Different Types of Hearing Loss

(University of Nebraska Medical Centre, 2003)

2.6.2.2 Sensorineural Hearing Loss

If the disturbance producing the hearing loss is situated in some portion of the sensorineural mechanism (such as the inner ear), along the cochlear nerve pathway to the brainstem, or in the central processing centres of the brain, a hearing loss by air conduction results (Goddard, 2011:193; Moore, 2004:61; Roeser & Downs, 2004:39). Martin and Clark (2000:16) explain that because attenuation (reduction) of sound occurs along the bone-conduction pathway, the hearing loss by bone conduction will be as great as the hearing loss by air conduction (see figure 2.6, Audiogram A). Sensorineural hearing loss is therefore caused by damage to the cochlea mechanism (the *sensory* end

organ or hair cells) and/or to the auditory nerve (*neural* pathway), while the functioning of the outer and middle ear is completely normal (Northern & Downs, 2002:10). This type of hearing loss is usually medically irreversible; the distortion of sound is only partly helped by amplification with hearing aids. Consequently, the loss is more permanent, and the implications far more serious (Goddard, 2011:193; Moore, 2004:61; Northern & Downs, 2002:10; Roeser & Downs, 2004:40; South African Association of Audiologists, 2010a).

Sensorineural hearing loss can be acquired before or during birth. Heredity, underdevelopment or early degeneration of the auditory nerve are all possible reasons for prenatal sensorineural loss. Sensorineural hearing loss can be acquired after birth through factors such as noise exposure, tumours, head injuries or toxic effects of drugs (Roeser & Downs, 2004:40; South African Association of Audiologists, 2010a). Bacterial and viral infections and even metabolic disorders can also lead to sensorineural loss (Northern & Downs, 2002:10).

The loss of hearing is usually different on all frequencies and individuals tend to find it difficult to hear their own voice or other voices normally. As a result they may struggle to regulate their voice level appropriately and might find coping in noisy situations very taxing. Individuals may also struggle with word recognition, as they are able to hear speech (in the low frequencies) but have difficulty understanding the words. This happens because the hearing loss means that many words sound similar in the high-frequency sounds (Roeser & Downs, 2004:40; Schröder, 2004:24). Another typical symptom of sensorineural hearing loss is a swift augmentation (growth) in loudness once the intensity threshold of hearing has been crossed, and is referred to as *recruitment*. This presents itself as a disproportional increase in intensity, and loud sounds can sound much louder than they truly are, causing extreme discomfort. The presence of recruitment is a signal that the location of the hearing loss is in the cochlea (Roeser & Downs, 2004:40).

2.6.2.3 Mixed Hearing Loss

According to Martin and Clark (2000:16), problems can occur concurrently in both the conductive and sensorineural mechanisms. This type of hearing loss is referred to as a mixed hearing loss and marks the occurrence of a significant conductive impairment superimposed on a sensorineural hearing loss (Roeser & Downs, 2004:42). This leads to a bone-conducting hearing loss because of the sensorineural abnormality, and an even greater loss of sensitivity by air conduction (Northern & Downs, 2002:10). Schröder (2004:25) notes that this type of hearing loss is rare among children.

A third way of classifying hearing loss pertains to the causes of the impairment.

2.6.3 The Cause of the Hearing Loss

Schröder (2004:26) and Ahlert (2009:49) state that causes for hearing loss are very intricate due to the complex nature of the hearing process. However, it is vital that hearing loss be detected as soon as possible. This should be followed by the appropriate investigation into causative factors in an attempt to make a prognosis and anticipate the course of the hearing loss, as well as to plan the proper intervention strategy for the impairment (Swanepoel *et al*., 2009). The early identification of the degree and type of hearing loss can guide specific educational and training. The earlier in the life of a child that these procedures can be initiated, the greater the chance of success (Martin & Clark, 2000:201).

At the school where the study sample was drawn, the children are assessed by a qualified audiologist and occupational therapists and integrated into the school system as early as 36 months of age. The age of admission is greatly dependent on the child's toileting and basic self-care abilities (such as eating, dressing etc.). According to Archer-Swanepoel (2010b), the average age for assessment and acceptance in the school system is around 42 to 60 months of age. The average age of diagnosis and intervention for children in the Western Cape is around 24 to 30 months of age, while the average in Gauteng is 31 to 43 months (Swanepoel *et al.,* 2009). It appears, therefore, that children in this rural area are diagnosed later in comparison to some other areas in

South Africa. This might have an unfavourable effect in their overall development, as intervention methods such as fitting hearing aids are only introduced later in life.

The sad reality for many children with hearing impairment at this school is that no definite cause of their hearing loss can be found. According to the school's audiologist (Archer-Swanepoel, 2010b), the reason for this is mainly because parents do not have any medical history other than a referral from the local hospital or nearby school to indicate that the child cannot talk. In the rural areas of South Africa, the availability of medical care before, during and after pregnancy is often poorly resourced in comparison to the private healthcare sector (Swanepoel *et al*., 2009). In the QwaQwa region where the study sample was drawn, more than 400 000 people are served by one regional hospital and one district hospital (Maluti-a-Phofung SDF, 2008). While working at the regional hospital in this area, the researcher witnessed how patients often wait until they or their children are severely ill before arriving for medical assistance. Although there are several clinics in the area, transport problems, lack in family support and financial difficulties were often given as reasons for not bringing children for medical checkups or treatment. Childhood diseases such as chronic middle ear infections (otitis media) are common due to the cold winters and it is rare to find audiologists and medical specialists in this rural area. Schröder (2004:27) noted that hearing loss causes vary with age and between geographic areas.

The common trend is to divide the causes of hearing impairment into three broad categories, namely prenatal, perinatal and postnatal.

2.6.3.1 Prenatal or Congenital Causes

Smith, Bale and White (2005) report that half of children with sensorineural hearing loss have inherited the impairment, while the other half are affected through environmental factors.

Environmental contributors to hearing loss frequently include viral infections contracted by the mother during her pregnancy. Although pregnant woman may be exposed to

several viruses during the course of their pregnancy, only a few of these infections damage the fetus and placenta (Smith *et al*., 2005). The nature and the severity of the damage caused to the embryo greatly depends on the stage of its development. For instance, if rubella (German measles) is acquired within the first 12 weeks of pregnancy, it may cross the placenta to infect the fetus and causes congenital malformation in more than 80% of cases (Best & O'Shea, 2003:198). In addition to hearing loss, children with congenital rubella syndrome may also suffer from visual loss, as well as behavioural and neurological dysfunctions (Smith *et al*., 2005). Hearing impairments can also result from sexually transmitted diseases (such as herpes), other viral infections (e.g., cytomegalovirus), from toxicity of certain medications (ototoxic – toxins damaging the ear) or treatments during pregnancy. As the environmental causes of hearing loss are usually associated with infections (e.g., pneumococcal respiratory infections), and epidemics (e.g., Human Immunodeficiency Virus (HIV) and tuberculosis), this might be one reason for the higher prevalence of hearing loss in South African children (Copley & Friderichs, 2010).

In most cases of nonsyndromic causes (hearing loss with no further physical or mental impairment), it is assumed that a recessive inheritance causes the hearing impairment in children of hearing parents. This means that although each parent has normal hearing, a gene for hearing loss paired with a normal gene can lead to a child with a hearing impairment. Parents with deafness giving birth to babies with deafness occur in about 7% of cases (see figure 2.7). The transmission of a mitochondrial gene mutation from the mother to the children, and X-linked inheritance, is a very atypical hereditary pattern that can cause hearing loss in less than 1% of hearing loss cases (Fischel-Ghodsian, 2004:180; Hertzano & Avraham, 2004:275).

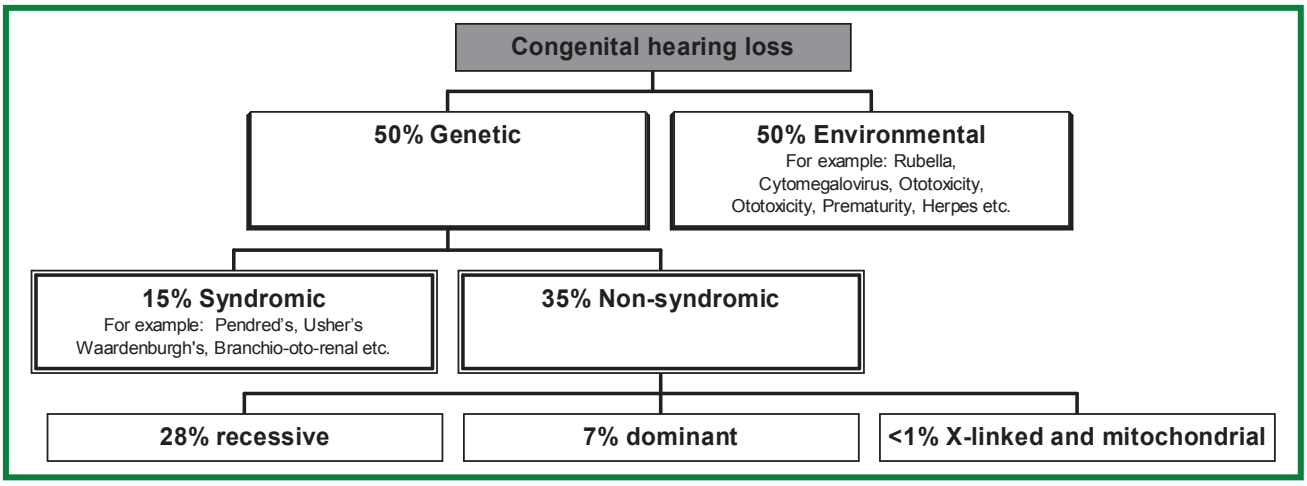

Figure 2.7 Genetic and Environmental Contributions to Congenital Sensorineural Hearing Loss

(Smith *et al.,* 2005:882)

Approximately 15% of cases of genetically-induced prenatal hearing loss have been described as known genetic syndromes accompanied by other behavioural and intellectual disabilities, such as Pendred's syndrome (characterised by malformation of inner ear and thyroid abnormalities), Usher's syndrome (characterised by retinitis pigmentosa and vestibular system pathology), Waardenburgh's syndrome (characterised by pigmentary anomalies and facial dysmorphic features) and Branchio-oto-renal syndrome (characterised by malformations in external, middle and/or inner ear). Syndromic hearing loss can vary in terms of age of onset, severity and progression. In the syndromes mentioned above, hearing loss is often the first feature recognised (Germiller, 2007:66-67). Copley and Friderichs (2010) suggest that the average primary caregiver rarely has the opportunity to see one of these syndromes. At the school where the study sample was taken, there were several children who were informally diagnosed with some of these syndromes. No specialists are working in the QwaQwa area to confirm these genetic syndromes (Archer-Swanepoel, 2010b).

Although sensorineural hearing loss is usually the result of prenatal causes, outer and middle ear malformations may be also occur as a result of hereditary factors or to disturbances during gestation (Northern & Downs, 2002:112).

2.6.3.2 Perinatal Causes

Complications during birth or soon after birth can also lead to a hearing impairment. There are several major causes of sensorineural impairment in the perinatal period (Ahlert, 2009:49; Adams & Rohring, 2004; Copley & Friderichs, 2010):

- Hypoxia (insufficient oxygen)
- Problems associated with prematurity and low birth weight
- Disorders associated with raised bilirubin levels (jaundice)
- Drugs used in the neonatal ICU (e.g., amino glycosides and frusemide)

Extremely preterm babies (31 weeks and younger), as well as very low birth weight babies (1000g – 1500g) are more likely to suffer episodes of hypoxia and, because of their immaturity, are generally more at risk of developing hearing impairments (Martini & Trevisi, 2004:56). As their immune systems are not fully developed, babies in general (and more so preterm babies) are prone to life-threatening infections. Equally, medication given for treatment of these infections may be ototoxic and potentially harmful to the infant's auditory system. Ototoxic drugs have the potential to damage the cochlea or the vestibular portion of the inner ear; and these findings have been well documented (Haubrich, 2007:306). Jaundice can be neurotoxic (causing damage to neural tissue or the nervous system), and is associated with damage to the auditory nerve in a newborn baby. It is therefore a risk factor in the development of hearing loss (Haubrich, 2007:306; World Health Organisation, 2010c).

2.6.3.3 Postnatal Causes or Acquired Disorders

Postnatal or acquired hearing loss occurs after birth, at any time in a person's life; and is usually the result of disease, a condition, environmental factors (e.g., constant high noise levels), or even injury (National Institute for the Deaf, 2009).

Otitis media is an inflammation of the middle ear (middle ear infection) and is associated with symptoms such as fever and pain. Otitis media can occur with any illness, but more often than not results from colds, sinus infections and allergies. This inflammation in the middle ear can sometimes be accompanied by a collection of liquid inside the middle ear

space, referred to as otitis media with effusion (Bluestone & Klein, 2007:2).

The load of otitis media is especially tough on children in areas of the world where medical care is limited. More or less all children with middle ear effusion will have some degree of temporary hearing loss. Untreated otitis media may lead to constant perforation of the tympanic membrane and displacement of the ossicles, causing permanent conductive hearing loss. Research indicates that recurrent episodes of otitis media, persistent middle ear effusion or otitis media in infants may predispose children to later experience disturbances of balance and high frequency hearing, as well as poorer performances on speech and language tests (Bluestone & Klein, 2007:328).

Hearing loss associated with otitis media is a particular concern in developing countries (Bluestone & Klein, 2007:329). The rural area from which the study sample was drawn, experiences inadequate medical care; and coupled with the cold winters and poor housing circumstances, otitis media is probably a frequent reality for children growing up in this area.

Bacterial meningitis is the most frequent cause of acquired sensorineural deafness in childhood; approximately 5% to 35% of patients are left with hearing loss after a bout of meningitis. In addition, the opportunistic infections commonly experienced in HIV, together with the effect of the virus on the cochlea and the ototoxic medications used to treat it can also cause a sensorineural hearing impairment (Hughes & Pensak, 2007:176 - 177).

Other causes include *brain tumours* and *trauma*. Sensorineural hearing loss can arise from primary tumours that grows within the temporal bone. Trauma can cause hearing loss in several ways. A blow to the head can damage the inner ear and central auditory processing if it is accompanied by a traumatic brain injury (Hughes & Pensak, 2007:177).

It is clear from the above discussion that the classification of a person's hearing loss can

be complicated. Archer-Swanepoel (2010a) adds that such a process can be made easier and more comprehensive in cases where multidisciplinary teams are involved and complete medical histories are available. Neither of these is easily accessible in the area where the study was conducted. The classification of hearing loss can assist with choosing the correct method of amplification. Amplification comprises a major component of the management of a hearing loss and should be considered for all as part of a total rehabilitation programme (Martin & Clark, 2000:389). The next section offers a brief overview on the concept of amplification.

2.7 AMPLIFICATION

The rationale for fitting a child with a hearing aid seems to be fairly logical. Ackley and Decker (2006:78) have little doubt that the degree to which a child can monitor speech and spoken language production by way of the auditory channel will influence these important developmental milestones. Therefore every child should be fitted with an appropriate hearing aid as soon as a hearing loss is identified. Studies indicate that those who do not receive appropriate amplification by six months of age will have poorer language skills compared to children amplified before six months of age (National Institute for the Deaf, 2009; Swanepoel *et al*., 2009). In general, the later in life hearing aids are suggested for a hearing loss, the poorer the prognosis for their successful use (Sandlin, 2000:59) and the more greater the impact on the development of language (Leigh & Power, 2004:xv).

Technological advances in the hearing aid, as well as the clearness of the speech signal, have improved in all categories of listening technology over the past three decades. These extraordinary achievements in hearing amplification have enabled many severely hard-of-hearing persons to use their remaining hearing more effectively (Ackley & Decker, 2006:78). The general assumption of those who manufacture and fit hearing aids is that each aid should be adjusted to maximise speech understanding. This enables the person with the hearing impairment to perceive soft sounds as soft and audible, average conversational sounds as comfortable, and loud sounds as perceived as loud, but not uncomfortably so (Sandlin, 2000:38, 597).

The study sample was drawn from a school where hearing aids have been a luxury. Even after the school received the financial support to obtain hearing aids, no qualified audiologist was regularly available to fit and adjust them. Over the last two years several children in the school have been receiving hearing aids, but very few of them actually use them as they are accustomed to communicating via sign language and struggle to use the aids successfully. The school has since employed a permanent audiologist and the aim has since been to fit all the young newcomers (especially in the foundation learning phase) with hearing aids. Unfortunately, the children are only allowed to use their hearing aids during school hours. The reason behind this seemingly illogical decision is based on the expensive nature of these fittings, the difficulty in getting broken hearing aids repaired in this area, as well as the youngsters' diminished sense of responsibility at their age. There were several incidences where the children's parents sold the hearing aids to pay for groceries or transport. Although most of the children in the sample have been fitted with a hearing aid, almost every child in the foundation phase uses sign language to communicate and has extremely limited speech and language skills. The hearing aids are mostly used to allow children to experience the natural sounds around them, such as cars driving by and animal sounds on the school premises (Archer-Swanepoel, 2010a).

Various types of amplification systems are available today. The choice of the correct and appropriate form of amplification must take into account variables such as the type of hearing loss, the onset of the hearing impairment, and the sensory, physical, emotional, intellectual, social and educational needs of the child (Schröder, 2004:33). In line with the purposes of this study, the following section focuses on different types of hearing aids, while only mentioning the cochlear implant as a choice of amplification. This electronic device performs the function of the damaged cochlea through direct electrical stimulation of the cochlea and the auditory nerve (Martin & Clark, 2000:402). As no child in the school or in this sample was using this form of amplification, this type of sensory aid is not examined in detail.

2.7.1 Children and Hearing Aids

Usually, the first selection for amplification for a child with a hearing impairment is a hearing aid, unless the child has been identified as a candidate for cochlear implantation. Hearing aids consist of the same four components as a public address system: a microphone, amplifier, loudspeaker (receiver) and a power source. Sound waves enter the hearing aid through the microphone and the acoustic energy is then converted into electrical signals. The electrical current from the microphone is then selectively processed and amplified by the amplifier. The receiver finally converts the amplified electric energy back into acoustic energy and sends it through the ear canal. A small battery powers the hearing aid system (Roeser & Downs, 2004:251-252). There are several different types, shapes and sizes of hearing aids today (see figure 2.8).

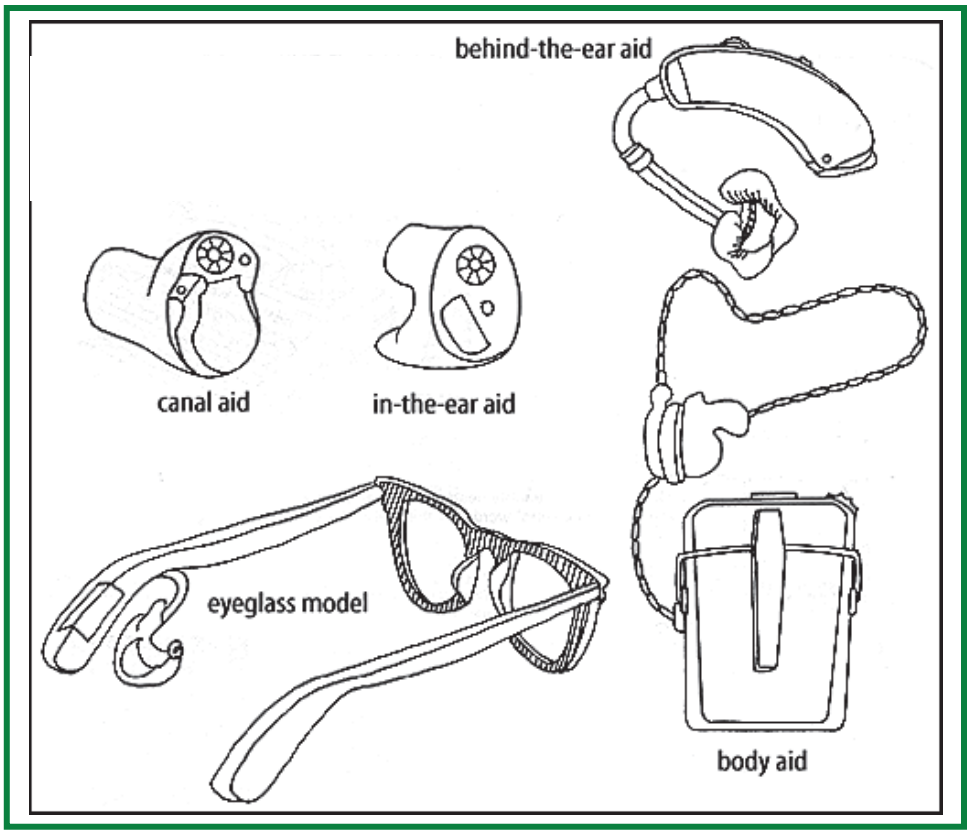

Figure 2.8 Different Types of Hearing Aids

(Laurent Clerc National Deaf Education Centre, 2010)

They include the body-type, eyeglass, behind-the-ear, in-the-ear, in-the-canal, and completely in-the-canal instruments (Martin & Clark, 2000:395). The components of the

body-type hearing aid are fitted into a case that clipped to the person's clothing. Body-type hearing aids are rarely used anymore and are seldom recommended for children (Martin & Clark, 2000:397; Northern & Downs, 2002:312). They are generally only used for very young children or those with severe disabilities (Roeser & Downs, 2004:253). Among the first attempts at head-worn amplification, hearing aids built into the temple bars of *eyeglasses* were common. The use of these hearing aids has diminished significantly in recent years (Martin & Clark, 2000:397).

Behind-the-ear, in-the-ear, and in-the-canal hearing aids are referred to as ear-level hearing aids. They offer the advantage of locating the microphone in a natural position at the ear. *Behind-the-ear (BTE) hearing aids* hook around the ear (Martin & Clark, 2000:398), and are widely used with children (Roeser & Downs, 2004:253) All parts of the *in-the-ear hearing aid (ITE)* fit entirely in the outer ear. The *in-the-canal (ITC) hearing aid* is even a smaller version, but is not often used with children due to the tiny controls and the fact that the hearing aid casing must be customised continuously as the size of the ear canal changes. The latest device available is the *completely-in-the-canal hearing aid (CIC)*. This instrument is so tiny that is rarely noticeable and fits deep in the external auditory canal where the amplified sound is closer to the tympanic membrane (Martin & Clark, 2000:399).

Over the years, technological advances within the amplification field (particularly cochlear implants) and sophisticated understandings of speech perception and acoustic phonetics, as well as literature on the social and communication needs of people with deafness influenced educational practices across the world (Leigh & Power, 2004:xiii-xiv). The following section provides a background to the literature on the education, language and communication of children with hearing impairment.

2.8 EDUCATION, LANGUAGE AND COMMUNICATION IN CHILDREN WITH HEARING IMPAIRMENT

Education for the hearing impaired in sub-Saharan Africa began as a result of the European missionary movement in the 19th century, but only reached a small proportion

in the region. Relatively rich African families living in urban areas were served, while those living in poor rural environments did not receive the same benefit. Most of the schools were strict auditory-oral and did not allow the use of sign language. In 1957, there were only 12 schools serving children with a hearing disability in the whole of Africa. Today, South Africa is regarded as one of four nations in sub-Saharan Africa that are leading deaf education on the continent (Kiyaga & Moores, 2003).

Educationists involved in the language development of children with hearing impairment remain embroiled in the ongoing dispute about spoken language versus sign language in education. For the first 60 years of the twentieth century, the focus of most researchers, as well as the wish of most parents, was to make sure that children with hearing impairment had access to speech, would be able to function in a variety of school and social settings, and appeared similar to their hearing peers (Marschark & Spencer, 2006:9).

In the early 1960s the world was introduced to the concept that visual-gestural communication had all the features of a natural language, and as a result the spoken language–sign language debate was revived (Marschark & Spencer, 2006:10). Information is still emerging about the value of specific approaches in deaf education (Marschark & Spencer, 2006:15), and currently parents should not be expected to embrace any specific method alleged to support the development of spoken language when research is unable to demonstrate its exclusive value (Davila, 2004:4; Leigh & Power, 2004:xv; Marschark, 2004:15; Marschark & Spencer, 2006:16-17).

What has been expected to provide an extra boost to the language development of the hearing impaired is the very early identification of hearing loss in infants. To take advantage of the critical periods of auditory neurological and linguistic development, Lim and Simser (2005) suggested that early identification, medical intervention and appropriate amplification are vital. This early identification and intervention is then followed by sign language or other communication approaches if so chosen by the parents (Marschark & Spencer, 2006:16; Swanepoel *et al.,* 2009).

Even though South Africa has a long-standing deaf education system, Times newspaper recently commented on the sorry state of deaf education in South Africa, in an article entitled "*Caught in the Deaf Trap*" (Van Rooyen, 2009). Some of the problems described were:

- Only 12 of the country's 47 schools catering for the hearing impaired offer matric.
- Only 14% of teachers are fluent in sign language.
- The functional illiteracy rate of hearing impaired South Africans is 75%.
- The unemployment rate for the hearing impaired in South Africa is 70%.
- South Africa has just one tertiary institution that caters for the hearing impaired, namely, the National Institute for the Deaf College in Worcester, while the number of students with hearing impairment in mainstream universities is negligible.

The Deaf Federation of South Africa (2009b) confirms these statements and adds that most teachers in the Foundation Phase do not have adequate signing skills to help children with hearing impairment to develop language. They add that the average child with a hearing disability will leave the school with a reading ability of an eight year old. Several recommendations were made by the Deaf Federation, for example, that schools need to adopt educational approaches that are shown to work in the best interest of the child with hearing impairment and that South African Sign Language (SASL) be adopted as a subject in these schools.

Generally, there are four communication approaches to teaching the child with a hearing disability (Lim & Simser, 2005). Each approach differs considerably in what it involves and in its overall objectives. Schröder (2004:40) believes that the best approach would greatly depend on the child's developmental progress and level of hearing, and should depend on the input from the child's parents and professionals involved with the child. Lim and Simser (2005) add that no one of these communication methodologies is designed to meet all of an individual's needs. Each approach could therefore be viewed as a possible modality to be used in education and language development. A concise overview of the four approaches follows.

2.8.1 Auditory-Oral and Auditory-Verbal Approaches

The simple goal of all oral methods of educating children with hearing impairment is to give them adequate familiarity and skill with listening and speaking so that they have enough knowledge of the sound and structures of language. Supporters of this approach believe that opportunities for higher education and employment are less restricted, and that fewer restrictions are experienced in social and personal lives (Beattie, 2006:106-107). Increasing numbers of children with hearing impairment are enrolled in standard school programmes and many receive cochlear implants today (Marschark & Spencer, 2006:14). Both early diagnosis and the efficiency of these implants, which give greater access to auditory information, have driven the interest in auditory-verbal and other oral approaches to developing language in children with hearing loss (Marschark & Spencer, 2006:15). In most auditory approaches the commitment from professionals and parents is crucial (Lim & Simser, 2005).

The *auditory-oral (AO)* approach typically focuses on educating children within a school with other children with deafness. The emphasis is often on auditory teaching and group instruction sessions (Lim & Simser, 2005). This method totally excludes the use of any natural signs or gestures (Shröder, 2004:40). Historically, the AO approached generally allowed the child to lip-read, therefore encouraging children to increase spoken language skills by combining auditory and visual cues (Beattie, 2006:112). Modern AO enthusiasts do not focus attention on lip-reading or natural gestures, but also do not minimise exposure to these visual channels (Beattie, 2006:113).

The *auditory-verbal* approach (AV) is based on the notion that most children with mild to profound hearing loss can learn to communicate through spoken language if provided with suitable amplification, ample listening, and language stimulation to develop their hearing potential. This approach optimises residual hearing by teaching children with hearing impairment to learn to listen and understand spoken language in order to communicate through speech. The child's access to lip-reading is usually restricted, while there is a strong focus on individualised and diagnostic therapy sessions. The objective of this approach is to support children with hearing loss to grow up in normal

learning and living environments and become autonomous, participating and contributing citizens in society (Beattie, 2006:110; Lim & Simser, 2005).

2.8.2 Total Communication (TC)

The model of *total communication* emerged in systems where signs were produced in the same order as spoken language and accompanied by speech. The total communication approach combines methodologies that emphasise hearing, facial expressions, lip-reading, speech and natural signs. The signing of TC, however, is a signed form of the language. A sign can therefore be produced simultaneously with each word that is spoken. Practically it takes much longer to sign a sentence this way. Many once again hoped that this recipe, combined with advances in hearing aids, would support the acquisition of spoken language. Despite intensive efforts, this approach has not been found to considerably increase the levels of literacy or spoken language achievements in children with a hearing loss (Lim & Simser, 2005; Lynas, 2005; Marschark & Spencer, 2006:11–12; Spencer & Tomblin, 2006:177).

2.8.3 Sign-Bilingualism Approach

Many *bilingual approaches* favour sign language and written literacy as opposed to spoken language. This approach is motivated by the argument that in order for children with hearing impairment to be guaranteed full human rights and equal opportunities, they should be presented their 'natural' language as a first language. It is argued that it is not fair to use spoken language as the medium of communication for the child with hearing impairment. The TC and the oral approaches unfairly impose speaking goals on the child with hearing impairment that they can never attain (Lynas, 2005).

The focus on an exclusively visual language system does not take advantage of the auditory speech perception skills provided by hearing aids. As a result few children enrolled in such settings have received cochlear implants. The better recognition of the value of naturally developed sign languages and the contact they offer to the social and emotional development of the child with deafness has sustained interest in approaches that use visual methods such as signing (Geers, 2006:257; Lim & Simser, 2005;

Marschark & Spencer, 2006:15).

The school used in this study uses the latter approach in teaching the children with hearing impairment to communicate. Sign bilingualists reason that once formal schooling begins, the child with hearing loss can be offered the full curriculum through the medium of sign language. They may then have the same prospects as hearing children to obtain knowledge and perform academically (Lynas, 2005).

The age-old dispute over whether children should be educated orally or by sign language has been debated over the world and in South Africa it is no different. South Africa has schools for the hearing impaired where oral approaches are strictly followed, as well as schools which support the notion that the deaf should be taught in their natural language. In her study of a South African school that follows the oral approach, Schröder (2004:20, 42) argues that the signing Deaf might be excluded from society, especially in South Africa where Deaf communities are in the minority and interpreters not freely available. Professionals teaching at sign-bilingual schools differ in their opinion on this topic (Archer-Swanepoel, 2010a). This is hardly surprising, as Marschark (2004:15) notes that no evidence exists to indicate that learning sign language disrupts a child with hearing impairment's acquisition of spoken language, while Lynas (2005) concludes that there is a lack of confident research to prove that the sign-bilingual approach will lead to competence in any language, whether spoken or written.

Parents have the responsibility to choose the communication method for their child with hearing disability. According to Lynas (2005), the most significant question is which methodology will be least constraining in adulthood. In the QwaQwa area, the parents of the sample children did not have the luxury of choice. Apart from the financial implication of special schooling, the only school that caters for the deaf in the area follows a strict sign-bilingual approach.

Pottas (2004:3) undertook a study to determine the challenges posed to teachers of

children with a hearing disability in inclusive education systems. The results of a literature review led Pottas (2004:10) to conclude that better knowledge and understanding of children with hearing loss is important to making appropriate adaptations to curricula and teaching strategies. Although the focus of the current study is on the child with hearing impairment in a special school, the same principle applies. The knowledge of the unique characteristics of a child with hearing loss provides a frame of reference in which the barriers to learning for these children can be identified and handled (Pottas, 2004:40). Knowledge of specific learning barriers for children with hearing loss was also considered important in choosing neurodevelopmental movements for the current study.

In addition to understanding the classification of hearing loss, the different communication methods used in schools, and the challenges in our rural education system, it is also important to have a sense of the overall impact of hearing loss on a child's development. The following section provides a brief overview of this. A more comprehensive view on normal child development, developmental delays and neurodevelopmental constructs is presented in chapter three.

2.9 THE IMPACT OF HEARING IMPAIRMENT

It should no longer be necessary to point out that a hearing loss can significantly affect the whole life of a child (Pottas, 2004:42). Hearing loss has long been documented as being an immense handicap linguistically, educationally and socially (Goddard, 2005:65). Whether hearing impairment is congenital or acquired later in life, it impacts on social, intellectual, and emotional development. Even relationships will invariably be affected by the child's hearing loss (Martin & Clark, 2000:218). Clinical experience indicates that infant and childhood deafness has a more overwhelming effect on hearing and receptive language than does hearing loss beginning during adolescence or adulthood. Deafness during the perinatal months may negatively impact on acoustic discrimination and attention to sound stimuli. In contrast, sound deprivation during early childhood (particularly in the first two years of life) may lead to deficits in cortical perceptual processes, ultimately affecting word learning (Moore & Linthicum, 2007).

Marschark (1993a:14) reports that deafness can bring with it the possibility of damage to other sensory systems, as well as neurological damage. Research has shown that approximately 40% of children with permanent hearing impairment have one or even more disabilities in addition to their hearing loss. These conditions can range from very mild learning disorders to severe disabilities (Waldman & Roush, 2005:41). Additional disabilities may include intellectual impairment autism, visual impairment, cerebral palsy, epilepsy, specific learning disorders, attention deficit disorders, emotional or behavioural problems, or physical disabilities. The presence of two or more disabilities may have significant consequences for communication, education, mobility, living skills and learning (Knoors & Vervloed, 2003:82; Martin & Clark, 2000:218).

Although the educational impact of the hearing loss will vary in each child according to the severity of the impairment as well as the comorbidity of other disorders, these children share several common characteristics in the following areas.

2.9.1 Hearing Impairment: Social and Emotional Development

The initial stages of social interaction between children with deafness and their mothers have large implications for cognitive, language, and social development. They set the stage for exploration, learning and further social relations as the child moves outside the mother-infant relationship and eventually beyond the familial context to deal with the rest of the world (Calderon & Greenberg, 2003:181; Marschark, 1993a:39). It is even possible that sounds in a hearing child's prenatal environment might affect the course of psychological and intellectual development. Prenatal auditory experience may exert powerful effects on postnatal learning, perception in humans, and may play a role in initial mother-child bonding (Schoeman, 2003:23-24).

Marschark (1993a:40) makes it clear that children with hearing impairment may not always be at any particular disadvantage; however, they may have different interaction strategies that have different consequences. This can be illustrated by imagining the interaction between a hearing parent and a baby with hearing loss. As the parent's soothing strategies do not yield a typical reaction from the baby (for example, the

mother's voice and singing is not successful in calming a crying baby), some parents end up feeling rejected, anxious and deprived from the lack of reciprocity. As a result, their social behaviour changes to accommodate the unexpected responses from their babies. Parents are more likely to model avoidance and physical action as methods for solving problems, and frequently report that they have limited options available for socialising with their children. In turn, the social interaction strategies acquired by children with hearing disability may be relatively restricted and are then generalised to persons outside the immediate family. These limited explanations from their parents and restricted experiences lead to restricted opportunities for children with hearing loss to learn to understand others (Calderon & Greenberg, 2003:179; Marschark, 1993a:43).

Pottas (2004:45) concurs that children who experience hearing loss have unique language and communication characteristics that may affect their social and emotional development. These children may struggle to communicate with family and friends, and frequently feel lonely and discontented, with few close friends. As a result, they may not have the same opportunities as hearing children to interact with adults and peers, and so may not acquire social competence skills. Possible outcomes of social incompetence include low academic achievement, underemployment, and higher rates of social maladaptive behaviours. Children with deafness tend to show greater impulsivity and poorer emotional regulation (Calderon & Greenberg, 2003:178). The availability of more diverse social, linguistic, and cognitive experiences can enhance the flexibility of young children with hearing impairment and equip them to better deal with later social interactions and the implications of growing up in a largely hearing world (Marschark, 1993a:52).

Marschark (1993a:38) considered that the context of deaf children's early social and emotional development is also the context for early cognitive and language development. From the work of Antonio Damasio (cited in Pascual-Leone & Johnson, 2004:216, 230) it is clear that emotions can play a role in thought and cognition. Damasio (cited in Kolb & Whishaw, 2009:558) emphasises that emotions are a cognitive process that contributes to logical thinking. Bodovitz (2007:176) agrees that emotions

are inseparable from thought, and have an effect on subsequent thoughts and behaviours. The physical state is part of the emotion and thus one ultimately thinks with both the brain and the body. Therefore, as people experience the world, their impressions are processed through an emotional filter and the intensity of emotions determines the value, meaning and memory potential of the experience in relation to past experiences. The way that information is perceived, coloured by emotions, determines both the response to it and the potential to learn from it (Bluestein, 2001:19-22). De Jager (2011:105) adds that without hearing, the wiring of certain parts of the brain (specifically the limbic system) is weaker and that children may behave in emotionally immature ways as a result.

2.9.2 Hearing Impairment: Language and Cognitive Development

Pottas (2004:43-44) reports that children with hearing loss show slower vocabulary development, less flexibility in language skills, difficulty in understanding analogies, in learning content words, understanding combinations, and initiating or maintaining conversations; and also experience problems in monitoring their own speech through auditory feedback. On average, the spoken language of children with a hearing disability is delayed relative to hearing children (Blamey, 2003:242). Added to that, most deaf and hard-of-hearing students do not read as well as their hearing counterparts upon graduating from high school. Paul (2003:97) reports that the average 18 to 19 year-old student with deafness reads at the level of the average eight to nine year-old hearing student. The Deaf Federation of South Africa (2009b) confirms this, reporting that in South Africa, the average child with a hearing disability leaves school with a reading ability of an eight year-old.

Humans are neurologically wired to develop spoken language and reading skills through the central auditory system (Lim & Simser, 2005). Most people might think that the skill of reading is only visually controlled, but recent research on brain mapping indicates that primary reading centres of the brain are located in the auditory cortex (Lim & Simser, 2005). This explains why children born with hearing loss and without access to auditory input during their childhood years have great difficulty reading, even thought their vision

is intact. Roeser and Downs (2004:287) concur that until the primary problem of hearing impairment is identified and managed, and the brain has access to detailed sound, interventions aimed at secondary levels of spoken language, reading and academics are likely to be ineffective.

Early detection and intervention have been mentioned as vital to limit the overall negative effect that hearing loss has on a child. The longer the brain is deprived of auditory input, the greater the resulting sensory deprivation. This in turn causes a lack of sensory stimulation to the brain and not only prevents auditory learning, but also prevents neural growth (Lim & Simser, 2005). Sharma, Dorman and Spahr (2002) found that there is a sensitive period of about 3.5 years during which the human central auditory system remains maximally plastic (brain can change synaptic connectivity when stimulated) in the absence of normal stimulation. Neural plasticity is greatly reduced after the age of seven (a comprehensive discussion on brain plasticity follows in chapter three). The longer the deficiency of stimulation, the less the auditory brain growth and the greater the possibility that existing pre-wired auditory tracts will degenerate (Lim & Simser, 2005; Lynas, 2005). Early and efficient contact with meaningful sounds not only directs children's attention to sound, but gives them a better chance of developing spoken language, literacy, and good academic skills (Blamey, 2003:241; Lynas, 2005).

This section showed that children's lack of language can hamper the actualisation of their cognitive abilities and lead to educational challenges (Schröder, 2004:2). This may have profound effects on the individual's overall academic achievement and ultimate life success (Samson-Fang, Simsons-McCandless & Shelton, 2000).

2.9.3 Hearing Impairment: Behavioural Difficulties

It should come as no surprise that children suffering from hearing loss are at risk of developing a wide range of behavioural disorders or problematic behaviours (Edwards & Crocker, 2008:46). The previous sections indicated how profound the impact of a hearing loss can be on a child's development of language, cognitive skills, social competence and emotional wellbeing. The ability of children with hearing impairment to

understand what they are being asked to do, how to do it, and the consequences of their actions may be severely impaired.

Temper tantrums are considered normal within the first three years of a child's life. In toddlers with hearing impairment, the tantrum phase usually lasts longer, they have more frequent temper tantrums and they are experienced as being more intense (Edwards & Crocker, 2008:46).

The essential features of *Obsessive-Compulsive Disorder (OCD)* are recurrent obsessions (persistent ideas, thoughts or impulses) or compulsions (repetitive behaviours to reduce anxiety) (American Psychiatric Association [APA], 2000:456-457). OCD might be more difficult to diagnose in children with deafness due to their reduced ability to describe their thoughts. Nevertheless, Edwards and Crocker (2008:50) state that children with hearing loss's OCD symptoms might present to others as overly anxious or 'strange' behaviour.

Attention-Deficit/Hyperactivity Disorder (ADHD) refers to a cluster of symptoms mainly associated with inattention and/or hyperactivity and impulsivity. This disorder is found in 3% to 7% of all school-age children (APA, 2000:85, 90). Although approximately the same rates of this disorder are found in children with hearing impairment, Edwards and Crocker (2008:50) report that many more children with a hearing disability – between 30% to 40% – have difficulty in controlling their behaviour in a classroom setting. As the delay in language acquisition is associated with delays in the development of executive functions, children with deafness are more likely to experience difficulties in mastering affect regulation (controlling their mood and emotions), and verbally mediated self-control. This results in the behavioural manifestations of ADHD. Again, this disorder is very difficult to diagnose in children with hearing impairment, due to the many overlapping behaviours and complex relationships between different conditions associated with children with hearing impairment (Edwards & Crocker, 2008:51; Knoors & Vervloed, 2003:82).

Oppositional Defiant Disorder (ODD) is characterised by hostile behaviour, temper tantrums, anger outbursts, purposeful disobedience, and arguing (APA, 2000:100). There appears to be a higher incidence of this disorder among children with deafness (Edwards & Crocker, 2008:51). Diagnosis is again complicated by the possibility that Children with hearing impairment often present with more anger outbursts due to the escalating frustration they experience when others fail to understand them. Parents might have also modelled more aggressive discipline methods with their child with hearing loss, as a result of difficulties in communicating effectively (Edwards & Crocker, 2008:52).

Because of the overlapping characteristics of these disorders and other behaviours shown by children with hearing impairment, clinical disorders may be underdiagnosed in children with hearing loss. An alternative possibility is that the developmental difficulties and challenges accompanying loss of hearing cause these characteristics to be incorrectly diagnosed as clinical disorders in the hearing impaired.

2.10 CONCLUSION

This first part of this chapter described the auditory system and concepts related to the process of hearing. Discussions on disability and hearing impairment, prevalence in the population and classification of hearing loss followed. Methods of amplification were highlighted. The chapter concluded with a description of education approaches and the impact of hearing loss on a child's development. Throughout the discussion it was evident that hearing impairment has an impact on the child's overall development; and that early identification and intervention is essential in promoting optimal language development and, as a result, effective social and employment integration. With proper health care and rehabilitation services, the negative impact of hearing loss may be significantly reduced and support children growing up with this impairment to become important contributors to society. The next chapter considers child development and relevant developmental constructs.

CHAPTER THREE

CHILD AND NEURODEVELOPMENT

"…the developmental process is continuous and observable from conception to the final stage in human life."

(Gabbard, 1992:5)

"…those changes that arguably reflect the emergence of some more complex or more integrated system or structure."

(Bee, 2000:17)

3.1 INTRODUCTION AND CHAPTER PREVIEW

An understanding of child development is important not only in understanding its significance, but also to help identify developmental delays as early as possible, and so maximise treatment intervention. Through discussions of several interrelated developmental domains, this chapter explores how children develop and so become able to perceive, understand, process, recall and learn aspects about the world.

From the earliest literature on infant and childhood development, it is clear that those responsible for the care of children, such as medical doctors, paediatricians and child welfare professionals, need a thorough knowledge of what is regarded as normal and variations thereof in order to diagnose (Illingworth, 1975:1). For this reason, the researcher aimed to integrate different theories of normal development in this chapter. As this study aims to design and evaluate guidelines for a neurodevelopmental movement programme for children with hearing loss, developmental theories of normal child development need to be acknowledged.

The reader can thereafter expect to find an overview of research literature on various child developmental domains, including neurological, locomotor, personal-social, cognitive and language aspects. Reference is made to neurodevelopmental aspects

during the discussion of these domains, while an in-depth study with a specific focus on underlying sensory-motor systems follows in chapter four and is therefore not addressed in detail here.

3.2 DEVELOPMENTAL CONSTRUCTS

The concept of development is used in everyday conversation to roughly mean “change with age or change over time” (cf. Bee, 2000:17). Several views on this exist, and several important constructs or concepts are frequently used in the study of development. A brief overview of these constructs follows in this section.

In earlier literature, Gabbard (1992:7) referred to ***development*** as the process of change in an individual’s level of functioning. These changes could be either quantitative or qualitative in nature and is a product of growth, heredity, maturation, and experience. Bee (2000:17) used the word *development* to refer to a subset of changes with age. She referred to these changes as the emergence of a more multifaceted or a more integrated system. Development also refers to gradual, cumulative and orderly changes, both physical and psychological, that result in progressively more complicated behaviours and interactions over the course of a person’s lifetime (Slentz & Krogh, 2001:5). Salkind (2004:5) adds that this progressive series of changes occur in a predictable pattern. This pattern is the result of an interaction between biological and environmental factors. The researcher agrees with Keenan and Evans (2009:4) and Shaffer and Kipp (2010:2) in that development can broadly be defined as systematic continuities and patterns of change over time, which begins at conception and continues throughout the lifespan until death. Human development can be divided into stages. Table 3.1 offers a flexible framework for understanding the ***stages of human development*** throughout the lifespan of an individual.

Table 3.1 A Chronological Overview of Human Development

(Shaffer & Kipp, 2010:5)

Period of Life	Approximate Age Range
Prenatal period	Conception to birth
Infancy	Birth to 18 months old
Toddlerhood	18 months old to 3 years old
Preschool period	3 to 5 years of age
Middle childhood	5 to 12 (or so) years of age Until the onset of puberty
Adolescence	12 (or so) to 20 years of age The end of adolescence: The individual begins to work / becomes independent
Young adulthood	20 to 40 years of age
Middle age	40 to 65 years of age
Old age	65 years of age and older

The age ranges are approximate (Shaffer & Kipp, 2010:5). In this study the focus is on the four to eight year-old child, and therefore refers to children in the preschool and early middle childhood stages of development.

Development also occurs in different ***domains***, such as biological, social, emotional and cognitive (Schröder, 2004:47; Keenan & Evans, 2009:4). Locomotor development, personal-social development, hearing and speech, hand-and-eye coordination, and performance development were domains recognised by Ruth Griffiths (1954:31) when she developed the Griffiths Scales of Mental Development (a measure assessing a child's mental development, of which a full discussion follows in chapter five). Even though there appears to be a sequence of development within each developmental domain, the development in one domain may not run parallel with that in another domain. This is noticeable when, for example, a child's locomotor development is faster than his expressive language ability (Rossi, 2005:18). Development is directly related to the development of the nervous system (Harris, 1998:22, 74, 103, 156). A thorough explanation of this statement follows in section 3.3.1.

The early developmentalists may be divided into three focus areas: (1) those who studied physical growth and motor skills; (2) those who studied the cognitive components of development, including language and perception; and (3) those who concentrated on psychosocial aspects of development (Shaffer & Kipp, 2010:5). Over the years, those studying development have realised that this classification can be deceptive as it is generally found that changes in one aspect of development impact on other developmental aspects. Also, children's development is not identical because of differences in culture, gender, physical environment (such as poverty), social conditions (such as stress, anxiety, friends, family) and an host of other factors, which include the influence of peers, family interaction style, and the degree of stimulation received (Louw *et al*., 1998:21-24). Development is therefore now viewed from a more holistic perspective, emphasising the importance of interrelationships among all aspects of human development. Developmental aspects are related and proceed simultaneously during the development of an individual (Louw *et al*., 1998:9; Shaffer & Kipp, 2010:5). Although this chapter discusses development in terms of different focus areas or domains, it is only done so for descriptive purposes. The researcher supports the view that development is a holistic process and that changes in one aspect of a child's development will influence other developmental aspects. Although it is descriptively useful to divide this chapter into various developmental domains, it is important to remember that we are studying the development of an integrated child who has an interdependent mind and body. Schröder (2004:47) notes, however, that understanding childhood development in these specific domains will assist in interpreting test results and in understanding a child's overall behaviour and functioning in their environment.

A topic that has generated much controversy in developmental studies is the ***nature versus nurture*** question. *Nature* refers to the influence of our genetic inheritance on development. In contrast, *nurture* refers to the belief that the environment is mainly responsible for developmental growth (Keenan & Evans, 2009:15-16). Although the debate on the relative significance of these influences has raged for many years, most present-day developmental psychologists have accepted the fact that the interaction between hereditary and environmental influences is so complex that it is senseless to

regard one of the two as more important. The interplay between biological and environmental factors is now regarded as more important (Gabbard, 1992:17; Bee, 2000:14; Keenan & Evans, 2009:17). With this as background, another frequently addressed concept is that of whether there exists particular time periods during development where the interplay between environmental and other factors has a greater impact or influence on development.

Salkind (2004:42) supports Gabbard's (1992:18) view that a ***critical period*** is the best possible interval of time during which certain behaviours surface, and represents a point in development during which internal or external events have maximum impact. During a critical period, the individual is regarded as more susceptible to certain influences than at other times. It is referred to as a time when an organism is biologically prepared to acquire a particular behaviour (Salkind, 2004:43; Keenan & Evans, 2009:32). Some supporters of this concept believe that specific forms of stimulation must be present during the critical period for normal development to proceed (Gabbard, 1992:18), and that if this is not successfully achieved within this time span, the individual may experience difficulty with later tasks (Salkind, 2004:43). However, not all theorists agree that critical periods are a useful notion for considering all domains of development. Some refer rather to a period of time where the individual may be especially "sensitive" to specific influences, and more susceptible to a certain kind of change (Gabbard, 1992:19; Salkind, 2004:44; Keenan & Evans, 2009: 33;), and during which outcomes and changes are not so dramatic or limited by time (Salkind, 2004:42). However, Salkind (2004:44) proposes that critical periods do exist for some developmental aspects. This is illustrated by De Jager's (2010:17) comment that crawling in young babies may offer benefits in preparation for standing, walking, learning and working unaided. Missing out on this early developmental milestone means that the child does not experience the myriad of benefits that this developmental milestone offers. Crawling, for instance, develops skills such as postural control, muscle tone, balance, integration of different systems in the body, eye-hand coordination, focusing distance and pencil grasp. None of these skills can develop thoroughly from the confines of a baby seat (De Jager, 2010:16; De Jager, 2011:192-197; Goddard Blythe, 2004:185).

The researcher agrees with Salkind's (2004:42) statement that critical or sensitive periods should be viewed in the light of many other factors that also influence development, but nevertheless we should acknowledge the importance of certain critical periods, especially during the first years of an infant's life.

Schröder (2004:45) refers to ***developmental norms*** as the typical age during which certain phenomena appear; for example, when children take their first steps. According to her, these norms are simply averages and not absolutes, and only when the variation from the norm is extreme will there be grounds to regard a child's development as being advanced or delayed. Developmental norms are sometimes also referred to as milestones. Milestones refer to a recognisable pattern of development that children are expected to follow or knowledge or skills that children are expected to acquire at a certain age (Slentz & Krogh, 2001:33). De Jager (2010:2) adds that milestones are general trends that offer guidelines to indicate the progressive development of the brain. Although each child will develop in his or her unique way, using norms helps in understanding these general patterns of development while recognising the wide variation between individuals (Meggitt, 2006:1). Keenan and Evans (2009:98) confirm that some variability is normal and add that early advancement or a lack thereof is not necessarily a good predictor of the final level of development. However, several authors and researchers stress the value of reaching all developmental milestones, and doing so within a specific timeframe. For instance, Goddard (1996:101; 2005:142) explains that the achievement of specific milestones by a certain age greatly depends on the strict chronological sequence and rhythm of the reflex structure. The importance of reflexes on a child's development is discussed later in this chapter. Cheatum and Hammond (2000:19) agree that the sequence of reaching these milestones is important. One stage leads to another. De Jager (2010:2) adds that motor milestones have been found to have significance for future learning ability. She concludes that skipping motor milestones could influence future learning. In this study, developmental milestone norms are indicated where applicable and significant during discussions of the developmental domains in the sections that follow.

3.3 THE DEVELOPMENT OF THE CHILD

The preceding section offered definitions of development and several developmental constructs. The purpose of this section is to distinctively refer to the systematic continuities and patterns of change over time in the development of the child. Due to the neurodevelopmental focus of this study, a thorough overview on neurodevelopment and plasticity needs to precede discussions of developmental domains, such as locomotor, personal-social and the like.

Firstly, it is important to grasp some of the neuropsychological terms often used when referring to human development in general. Neuropsychology refers to the study of the relation between behaviour and brain function, where the brain refers to the tissue found within the skull (Kolb & Whishaw, 2009:2-3). It is assumed that there exists a causal relationship between the brain and behaviour. Neuropsychology offers several advantages for parents and school professionals in understanding the developmental course of learning, and social and behaviour difficulties in children (Semrud-Clikeman & Ellison, 2007:12). Interchangeable terms such as neurodevelopment, neural development and neurological development are used to describe the steady development of the nervous system (NS), including the brain (Cheatum & Hammond, 2000:29; Goddard, 1996:1; Hannaford, 2005:23; Kokot, 2010a:14). In this research report, the term neurodevelopment is used to refer to the developmental sequence of the NS.

3.3.1 Neurodevelopment

The study of neurodevelopment draws on both neuroscience and developmental biology to describe the cellular and molecular mechanisms by which complex nervous systems emerge during embryonic development and throughout life (Van der Westhuizen, 2007:108). The normal development of the NS occurs at different rates for different structures at different stages. Periods of growth occur, as do periods of inactivity. The sequence of development is consistent although some variation in the pattern can occur (Rossi, 2005:20). The NS is specialised to handle innumerable tasks simultaneously and is dedicated to making it possible for people to interact with their environment. This

specialisation starts during the time of embryonic development and only stops at the time of death (Vera-Portocarrero, 2007:12). The development of the different components of the NS can be categorised into distinct phases. These include the birth of neurons (neurogenesis), the migration of neurons to their correct location, the differentiation of neurons into their different types and their subsequent maturation of connections, and the pruning back of connections and cells themselves (Kolb & Fantie, 2009:21). From this initial discussion on neurodevelopment it is essential to understand that the NS and the human brain consist of billions of neurons. A neuron refers to the basic cellular structure of the NS. This basic cell (the neuron) transmits and receives nerve impulses throughout a complex network of interconnected brain cells (Semrud-Clikeman & Ellison, 2007:26).

In the following subsections consideration is given to the development of the NS as well as the human brain. Discussions will follow on the spinal cord, the brainstem, the cerebellumas well as various areas and structures inside the brain.The focus will then shift to a comprehensive discussion on neurons and glial cells.

3.3.1.1 The Development of the Nervous System and the Human Brain

At the time that an egg is fertilised by a sperm cell, a human embryo consists of just a single cell that will shortly begin to divide, forming a round lump of cells (Brodal, 2004:104; Kolb & Whishaw, 2009:656). From this lump of cells the embryo is transformed into an elongated disc after a week (Brodal, 2004:104). The first suggestion of nervous tissue development occurs about 16 to 18 days following conception, when a thickening appears along the complete dorsal length of the embryo (Brodal, 2004:104; Vera-Portocarrero, 2007:12). Figure 3.1 illustrates this thickening, which is known as the *neural plate*, and which differentiates and gives rise to all neurons and most glial cells (Bangalore, 2007:16-18; Vera-Portocarrero, 2007:12).

Figure 3.1 illustrates how the neural plate folds inwards to form a longitudinal neural groove in the midline that deepens as the neural folds approach each other in the midline and meet dorsally (Niewenhuys, Voogd & Van Huijzen, 2008:7; Vera-

Portocarrero, 2007:12). This sheet of cells rolls up to form a structure called the *neural tube* (Majoviski & Breiger, 2009:69), much as a flat sheet of paper can be curled to make a cylinder (Kolb & Whishaw, 2009:656) in a process referred to as neurulation (Niewenhuys, Voogd & Van Huijzen, 2008:7). This neural tube is the beginning of the brain and spinal cord (Vera-Portocarrero, 2007:12).

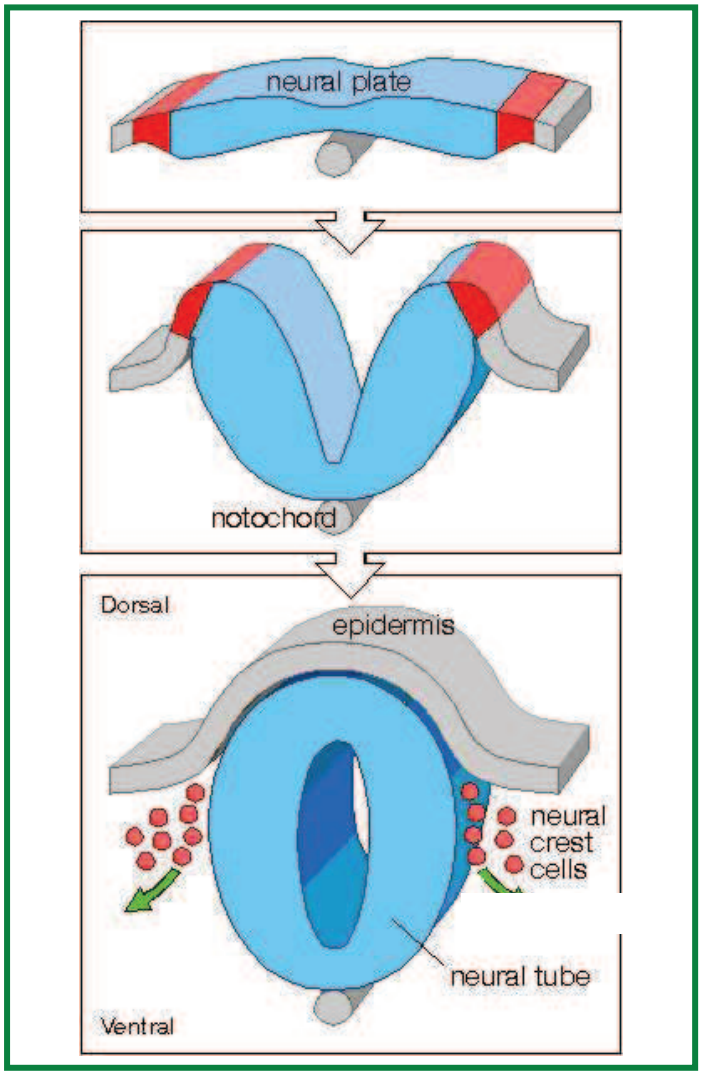

Figure 3.1 Formation of the Neural Plate and the Neural Tube
(Memorial University of Newfoundland, 2007)

A key regulator of the process of cell fate specification during development is a molecule called *notch.* This molecule facilitates cell fate decisions by controlling the ability of developing cells to respond to developmental signals. In doing so, it directs the position

of each cell within a developing organ (Bangalore, 2007:20). The lateral edge of the neural plate forms a distinct cell group, which later forms a longitudinal column on each side of the neural tube and is called the neural crest. The neural crest produces the neurons of the peripheral nervous system (cranial and spinal nerves) (discussed later in this chapter) (Brodal, 2004:105; Niewenhuys, Voogd & Van Huijzen, 2008:7; Vera-Portocarrero, 2007:12).

The neural tube has a cavity at its centre that is conserved throughout development and its interior remains hollow (see figure 3.1). The four main pockets created by the folding of this hollow interior develop into the ventricle system of the brain and the central canal of the spinal cord. It is in through this canal that cerebrospinal fluid (CSF) travels and bathes all of the central nervous system (CNS) (Kolb & Whishaw, 2009:60; Vera-Portocarrero, 2007:13). The human brain follows a general pattern of development, beginning as a neural tube and gradually acquiring the features of the adult brain (illustrated in figure 3.2) that is typical of all mammals (Kolb & Fantie, 2009:21).

Initially, three primary bulges appear in the brain region of the neural tube, namely the forebrain, the midbrain and the hindbrain (Majoviski & Breiger, 2009:69). As development continues, the neural tube advances into five different swellings that become the main divisions of the brain. Figure 3.2 illustrates these divisions in the growing baby's brain as the cerebral cortex, forebrain structures such as the thalamus, the midbrain, the cerebellum and pons, and the medulla (Vera-Portocarero, 2007:14). The remaining tube underlying the cerebral cortex is referred to as the brainstem, which is in turn connected to the spinal cord that descends down the back in the vertebral column (Kolb & Whishaw, 2009:4).

In prenatal development, the spinal cord forms before the brainstem, which forms before the forebrain. Functionally, the forebrain mediates cognitive functions; the brainstem mediates regulatory functions such as eating, drinking, and moving; and the spinal cord is responsible for sending commands to and from the muscles (Kolb & Whishaw, 2009:4). The functions performed in the forebrain are often referred to as higher-order

functions (cognitive functions), because they include thinking, perception, and planning. It is the largest region of the brain and regulates many emotional, motivational and cognitive processes.

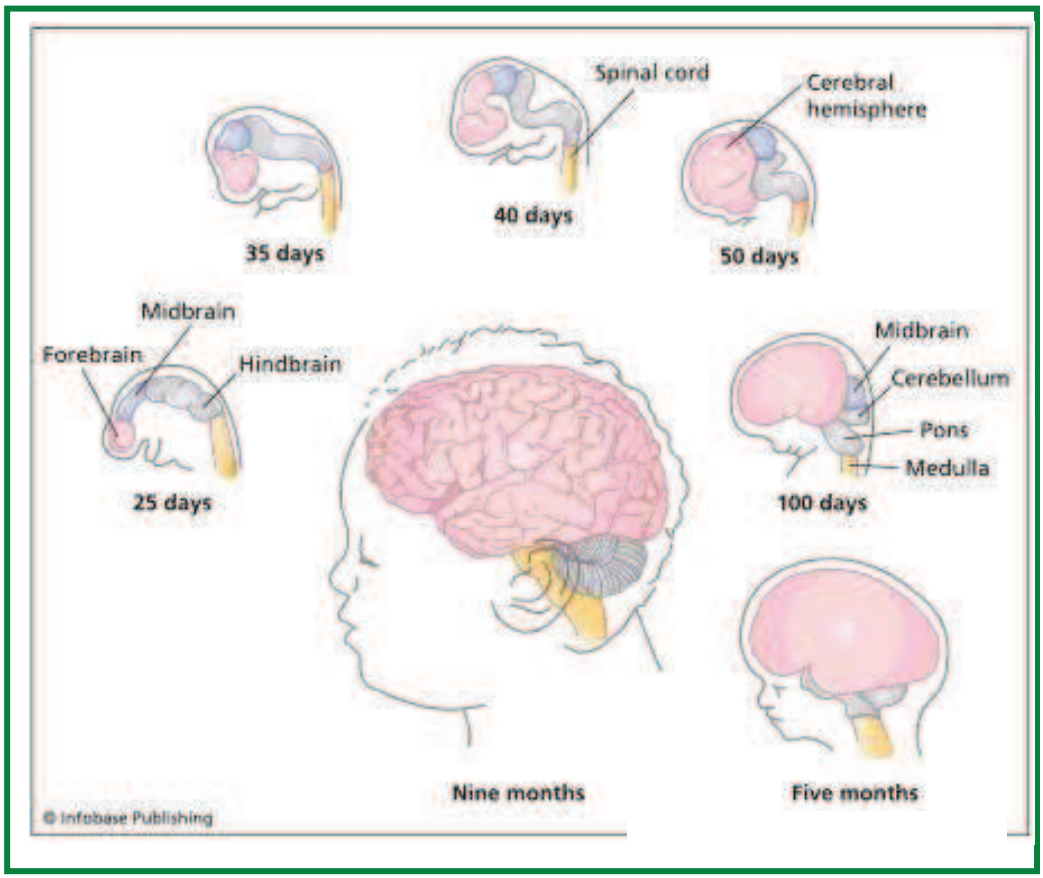

Figure 3.2 Progression of Brain Growth From Four Weeks After Conception to Birth.
(Vera-Portocarrero, 2007:14)

In contrast, the regulatory and basic life-sustaining functions (such as eating and drinking) and movement-producing functions of the brainstem and spinal cord are sometimes referred to as lower-level functions controlled by the hindbrain. It is the most primitive part of the brain and is named for its position at the bottom of the brain (Kolb & Whishaw, 2009:4; Pastorino & Doyle-Portillo, 2009:66).

Reviewing the functions of these different NS structures serves as a reminder of how imperative those first few weeks after conception are for the development of the NS. As the most basic structures of the NS are formed during the very early days of embryonic

development and throughout the very early months of pregnancy, maternal infection, malnutrition or chronic illness, drug ingestion, radiation, trauma, anoxia and even emotional stress during this time may have extremely harmful effects on the foetal nervous system (Cheatum & Hammond, 2000:29; Koch, 2009:27-28). Such harmful effects may lead to irregularities or errors in development that contribute to absent or severe deformities of brain structures. Less pronounced deficits may lead to such problems as learning disabilities or may appear only as subtle changes in behaviour (Kolb & Whishaw, 2009:657).

3.3.1.2 The Organisation of the Nervous System

The brain comprises many separate entities which are all interlinked and dependent upon each other (Goddard, 2005: 42). Figure 3.3 shows the mature human brain with two almost symmetrical halves (***hemispheres***), one on the left side of the body and the other on the right (Kolb & Whishaw, 2009:2-3), together known as the cerebrum (Keenan & Evans, 2009:108).

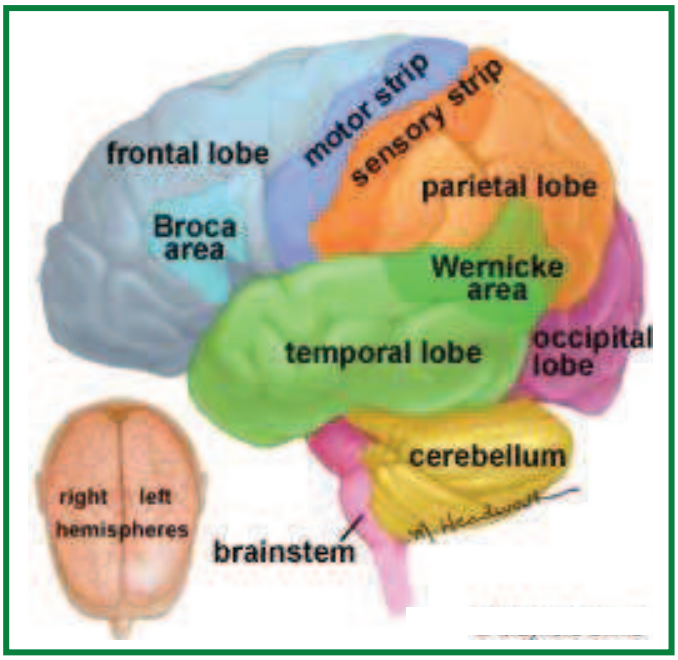

Figure 3.3 The Human Brain

(Mayfield Clinic, 2010)

Bangalore (2007:6-8) explains that the adult human brain can be divided into three major units, one of which is the cerebrum. The other two units are the cerebellum and the brainstem. These structures are arranged from top to bottom around the central axis

of the brainstem. In evolutionary terms the most advanced part of the brain is the ***cerebrum***. The ability to learn through reasoning, intuition and perception is due to this structure. It controls our conscious thoughts and voluntary movements.The crinkled outer layer of the cerebrum is referred to as the ***cerebral cortex*** (or just the cortex) and appears greyish in colour (therefore sometimes referred to as grey matter). The cortex is a laminated structure of approximately six layers made up of neurons and glial cells. Some glial cells in the brain insulate certain portions of neurons by wrapping around them, while others are thought to perform basic maintenance and support functions for neighbouring neurons (Ayres, 2005:33; Hoffelder & Hoffelder, 2007:13-15; Kolb & Fantie, 2009:21).

Just beneath the cerebral cortex is the subcortical white matter, responsible for information transmission (Bangalore, 2007:8). There is some disagreement over how long it takes for the cells destined for the cortex to divide and migrate in humans, but most cortical cell proliferation appears to be complete by the middle of gestation. At that stage the cortex does not yet resemble that of an adult; and cell migration continues postnatally as cortical lamination continues to differentiate and develop after birth. An intriguing feature of brain development is that the cortex overproduces neurons, which are later lost due to normal cell death. The motor cortex is a particularly clear example of this: cells that are visible there during the seventh month of gestation and at birth later degenerate, leaving an agranular layer (Kolb & Fantie, 2009:23).

Figure 3.3 presents a guide to the orientation of the adult brain and its lobes. The cortex of each hemisphere is divided into the temporal lobe (above the ear), the frontal lobe (above the temporal lobe and in front of the brain), the parietal lobe (behind the frontal lobe), and the occipital lobe (the area at the back of the brain) (Baehr & Frotscher, 2012:9-4). According to De Jager (2011:69), Hannaford (2005:83-84), Kolb and Whishaw (2009:350, 376, 405, 429, 433) and Semrud-Clikeman and Ellison (2007:38-45), these four main lobes have the following important general functions:

- *Frontal lobe:* This lobe controls behaviour in response to social and environmental situations. It is part of the thinking brain and is involved in planning

and selecting options, ignoring extraneous stimuli and keeping track of important bits of information. The primary and the premotor areas have major motor functions, control specific muscles all over the body, and are responsible for voluntary and planned movement. Reasoning and planning also takes place in the prefrontal cortex.

- *Parietal lobe:* This lobe processes and integrates somatosensory and visual information, especially with regard to the control of movement. It plays a central role in the perception of tactile sensory information, such as pain, pressure, cold and heat. It is also linked to spatial orientation and taste.
- *Occipital lobe:* This lobe controls visual intake and the interpretation thereof. It receives sensory impulses from the eyes and interprets shape, colour and movement. The visual association area deals with present visual experiences, recognition and evaluation of that which is seen.
- *Temporal lobe:* This lobe houses the primary auditory cortex and plays in important role in the processing of auditory input, visual object recognition, as well as the long-term storage of sensory input – that is, memory. This part of the brain is also responsible for balance and smells.

A specific region within the cerebral cortex (refer to figure 3.3) is the ***motor cortex***, which controls voluntary movement of muscles. Another region is called the ***sensory cortex*** and this region processes information from the sense organs. Most of the activities of the NS originate through sensory experience emanating from sensory receptors. These receptors can be visual, auditory, tactile, as well as balance or other kinds of receptors. The main region in the sensory cortex that receives sensory information is the somatosensory area (refer to figure 3.4).The somatosensory area receives sensory input in a strip running across the parietal lobes of the brain and lies posterior to the motor strip, where it is then passed onto for muscle response. The surface of the entire body is mapped across both these strips and this map is called the homunculus (Kolb & Whishaw, 2009: 225; Van der Westhuizen, 2007:132).

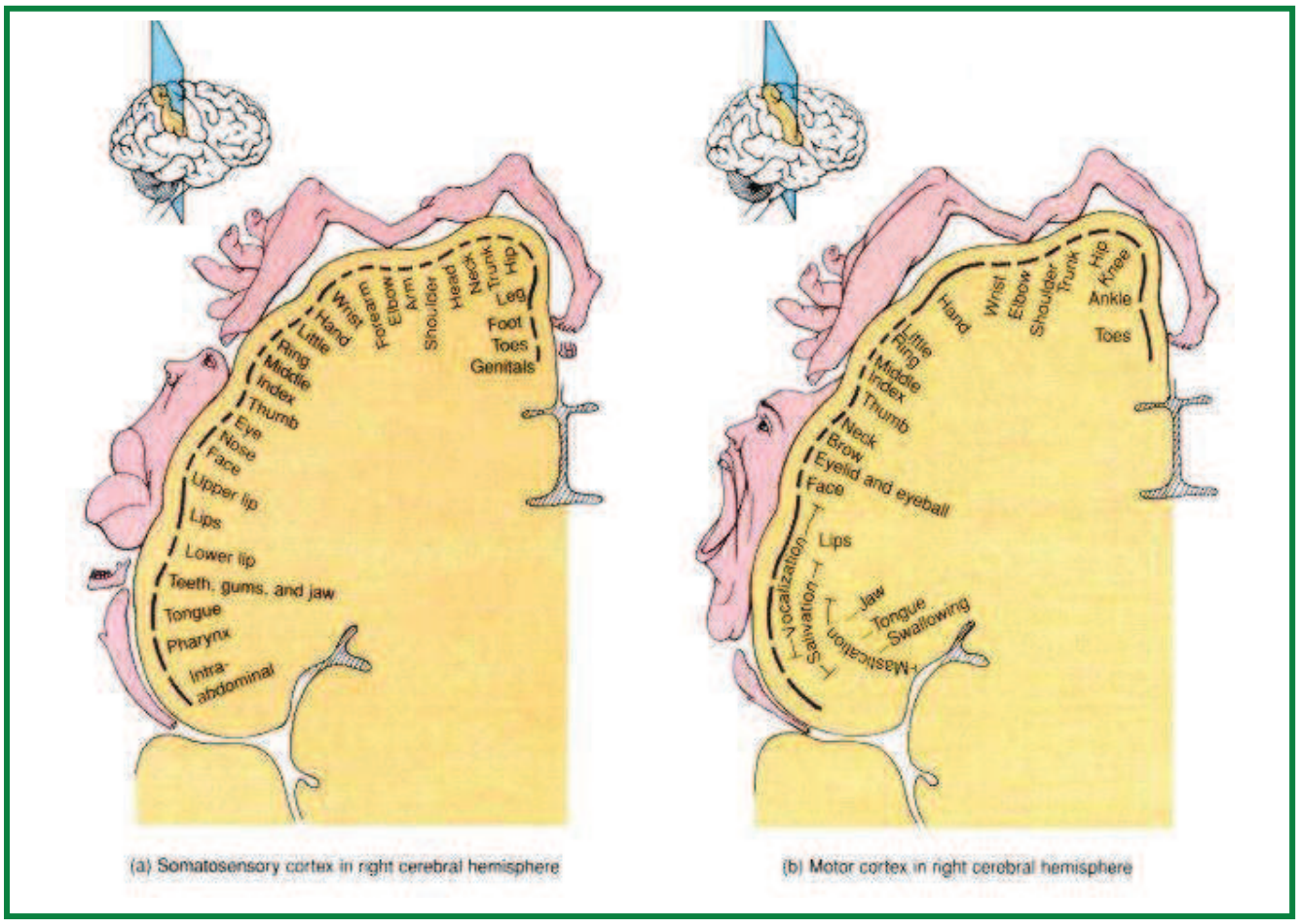

Figure 3.4 Somatosensory and Motor Cortex

(Rollins College, 2008)

A ***homunculus*** is a schematic mapping of brain function into specific body structures. Thus, there is a specific region that is responsible for movement of the thumb or ankle or the nose that maps onto the primary motor cortex (Semrud-Clikeman & Ellison, 2007:39). In both the motor and somatosensory cortices, the most striking feature of the homunculus is the disproportion in the relative sizes of body parts compared with its relative sizes in the body itself (see figure 3.4). The homunculus has very large hands with an especially large thumb. It also has very large face, lips and a large tongue (Kolb & Whishaw, 2009:226). These represent the most sensitive and discriminating sensation areas in the body, which have the largest proportion of touch receptors (Zillmer, Spiers & Culbertson, 2008:182-183). These size distortions are because large parts of the motor cortex regulate hand, finger, lip, and tongue movements, giving us

precise motor control over those body parts. At the same time, speech production requires multiple sensory inputs from these muscles to provide sensory feedback. Parts of the body over which we have much less motor control have a much smaller area of representation in the motor cortex (Kolb & Whishaw, 2009:226; Semrud-Clikeman & Ellison, 2007:40). Van der Westhuizen (2007:132) adds that the mouth and the thumb thus play a large role in the brain's processing of sensory input and that these sensitive areas are also responsible for early learning experiences.

The brain's two hemispheres are connected by commissures, which are neural pathways (sets of nerve fibres). The largest of these is the ***corpus callosum*** (Baehr & Frotscher, 2012:9-2; Goddard, 2005:49; Hoffelder & Hoffelder, 2007:15; Keenan & Evans, 2009:108; Kolb & Whishaw, 2009:3; Shaffer & Kipp, 2010:206). Goddard (2005:49) indicates that although some tasks are shared by both hemispheres, the two sides of the cortex have specialised functions to perform. They are, however, dependent upon each other for the execution of those tasks, hence the significance of the corpus callosum that joins them. For most people, language, mathematical and analytical abilities seem to be handled predominately in the left hemisphere. The right hemisphere handles artistic and musical abilities, abstract reasoning and the manipulation of objects in space (Hoffelder & Hoffelder, 2007:16).

The cortex constitutes most of the forebrain, so named because it develops from the front part of the tube that makes up an embryo's primitive brain (refer to figure 3.2). Kolb and Whishaw (2009:70) explain that of the three main forebrain structures, two are subcortical. They are the basal ganglia and the limbic system. The ***basal ganglia*** are found at the base of the cortex and play an important role in the initiation and modulation of movement and in the control of muscle tone (Baehr & Frotscher, 2012:6-50). It is responsible for the organisation of involuntary and semi-voluntary activity, upon which consciously willed movements are superimposed. They receive input from the cortex and then influence movement by affecting the output of the motor cortex. Ongoing movements are constantly adjusted, and as such the balance between inhibitory and facilitating influences are maintained (Goddard, 2005:44). When a particular part of the

basal ganglia is damaged (such as in Parkinson's disease) the inhibition of involuntary movement is impaired. This explains the presence of continuous tremors when the patient is at rest found in conditions such as Parkinson's (Baehr & Frotscher, 2012:6-50; Goddard, 2005:45). The person also becomes rigid and has difficulty moving and maintaining balance. The basal ganglia therefore play a role in the control and coordination of movement patterns, and not in the activating of muscles (Kolb & Whishaw, 2009:70). The ***limbic system*** consists of a number of interrelated structures (such as the amygdala, hippocampus and the septum) that lies just above the corpus callosum along the medial walls of the cerebral hemispheres. The amygdala and the septum play roles in emotional and species-typical behaviours. They regulate emotions like fear, arousal and anger (Hoffelder & Hoffelder, 2007:27). The hippocampus is proposed to mediate memory and spatial navigation and is particularly vulnerable to the effects of stress (Kolb & Whishaw, 2009:71). Memories stored in many parts of the brain are indexed here (Hoffelder & Hoffelder, 2007:27). The limbic system is often referred to as the "emotional brain" as it has much to do with receiving, interpreting and controlling emotional experiences (Hoffelder & Hoffelder, 2007:25).

The NS consists of the brain and spinal cord and the neural tissue that extends into all parts of the body (Sigelman & Rider, 2009:6). More specifically, the NS is divided into two basic systems: the peripheral (PNS) and the central nervous system (CNS). The brain and the spinal cord together (refer to figure 3.5) are called the CNS, which forms part of the NS (Cheatum & Hammond, 2000:40; Majoviski & Breiger, 2009:68). Fundamentally, the CNS governs prenatal and early developmental reflexes and reactions that are involuntary, while the PNS is involved in the body's voluntary movements (Cheatum & Hammond, 2000:40). A thorough discussion on reflexes follows in subsequent sections in this chapter.

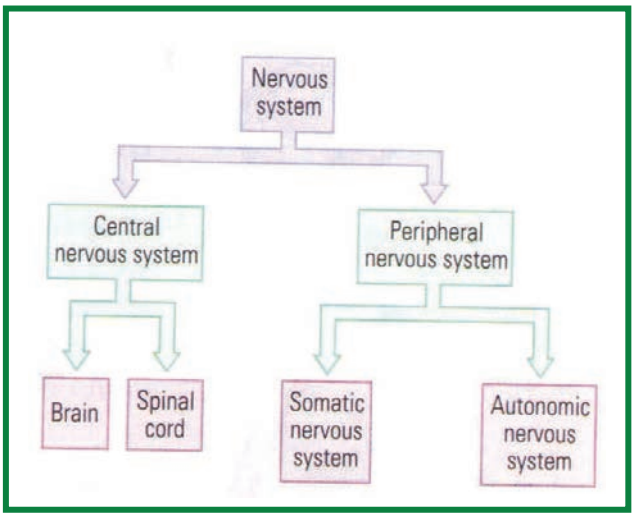

Figure 3.5 Anatomical Divisions of the Human Nervous System

(Kolb & Whishaw, 2009:5)

One of the major functions of the ***spinal cord*** is to connect the brain and the body via large sensory and motor neurons. Neurons leave the spinal cord and enter into muscles and organs. Motor commands from higher cortical centres are then conducted at these sites. Sensory receptors connect with motor neurons in the spinal cord and allow the spinal cord to conduct signals to and from the higher cortical areas, as well as the cerebellum, the brainstem and cortex. Unlike the brain, the spinal cord has little diversification or specialisation, but it does carry out sensory, motor and integrative functions. Four such functions are carried out in the spinal cord: (1) reflex activity, whereby a stimulus is followed by a coordinated motor response; (2) reciprocal activity, whereby one activity starts or stops another; (3) monitoring activity, whereby incoming messages are controlled, coded and transmitted, and (4) transmission activity, whereby messages are transmitted to and from the brain (Semrud-Clikeman & Ellison, 2007:30). Simple reflexive movements controlled only by nerve cells in the spinal cord ensure that as one group of muscles contract, the opposing set relaxes. Spinal reflexes can be modified by higher levels in the brain (Goddard, 2005:42).

Both the spinal cord and the brain are surrounded by a protected layer of tissue referred to as the ***meninges***, which comprises three layers (Baehr & Frotscher, 2012:9-39; Niewenhuys, Voogd & Van Huijzen, 2008:97). As this study focusses on the learner

with hearing impairment and as many of the study's sample have had meningitis, it is worth noting that bilateral infections that attack the meninges, such as meningitis, can have serious consequences for the developing brain. Large cavities filled with cerebrospinal fluid (CSF), referred to as the ventricles, reside in various regions of the brain. They provide equilibrium and allow the CSF to transport nutrients and waste throughout the brain. When these ventricles appear enlarged a diagnosis of a tumour or disease (such as meningitis and several others) may be made (Semrud-Clikeman & Ellison, 2007:30-31).

The peripheral nervous system (PNS) is made up of all the nerve fibres that enter or leave the brainstem and spinal cord to supply the sensory receptors, muscles, internal organs, and glands with information. The PNS consists of the spinal, cranial and peripheral nerves that connect the CNS to the rest of the body (Majoviski & Breiger, 2009:68; Semrud-Clikeman & Ellison, 2007:30). Table 3:2 lists the cranial nerves and gives a brief overview of their functions.

The nerve fibres of the PNS enable the brain to sense what is going on in the world around one and within one's body (Gabbard, 1992:39; Kolb & Whishaw, 2009:4), and thus ensure that the CNS is informed (Pastorino & Doyle-Portillo, 2009:62).

Table 3.2 Cranial Nerves Overview

(Nikoletseas, 2010:74, 78, 105, 113, 136, 139, 140; Semrud-Clikeman & Ellison, 2007:30; Wilson-Pauwels, Stewart, Akesson & Spacey, 2010:29, 56)

Number	Name	Function
1	Olfactory	Smell
2	Optic	Vision • For visual information from the retina

3	Oculomotor	Eye movement • Innervates four of the six extrinsic extra-ocular muscles (muscles around the eye) • Innervates the intrinsic ocular muscle (pupil muscle) • Innervates the upper eye lid muscle
4	Trochlear	Eye movement
5	Trigeminal	Masticatory movements (chewing) Sensory to the face • Innervates the cornea, iris, nasal cavity mucosa, skin of eyelids, eyebrow, forehead, cheek, lower jaw and nose • Innervates upper lip and palate • Innervates proprioception for teeth
6	Abducens	Eye movement
7	Facial	Facial movements – a motor nerve to the muscles of the face
8	Auditory Vestibular	Two components: • The cochlear nerve (hearing) o The cell bodies of this nerve reside in the cochlea. The cochlea transduces sound stimuli to neuronal impulses. The fibres of this nerve terminate in the auditory nuclei of the brainstem. • The vestibular nerve (equilibrium) o The cell bodies of this nerve reside in the labyrinth (vestibular system). This organ transduces gravity and motion stimuli to neuronal impulses. The fibres of this nerve terminate in the vestibular nuclei in the brainstem.
9	Glossopharyngeal	Tongue and pharynx
10	Vagus	Heart, blood vessels, viscera, movement of larynx and pharynx
11	Spinal accessory	Strength of neck and shoulder muscles and viscera
12	Hypoglossal	Tongue muscle

The structures of the CNS transmit information about the environment and the body to the brain for processing and storing. The CNS also carries information from the brain to muscles and glands, thus producing motor responses and the body's adaptations to environmental demands (Gabbard, 1992:39).

Collections of nerve fibres (organised into sensory pathways for specific sensory organs) carry information collected on one side of the body to the cortex in the opposite hemisphere by means of a subdivision of the PNS called the ***somatic nervous system*** (SNS). Motor pathways refer to the group of nerve fibres that connect the brain and the spinal cord to the body's muscles through the SNS. Again, one hemisphere uses muscles on the opposite side of the body to produce the movement (Pastorino & Doyle-Portillo, 2009:63). The SNS is monitored and controlled by the CNS. The spinal cord oversees the spinal nerves, and the brain oversees the twelve pairs of cranial nerves. Cranial nerves may have afferent functions, such as sensory inputs to the brain from the eyes, ears, mouth, and nose, or they can have efferent functions, such as motor control of the facial muscles, tongue and eyes (Kolb & Whishaw, 2009:65). Some (e.g., the trigeminal nerve) combine both afferent and efferent functions.

Sensory and motor pathways that control the muscles of one's internal organs (such as heartbeat and the stomach contractions) form a subdivision of the PNS called the autonomic nervous system (ANS) (Kolb & Whishaw, 2009:4-5; Pastorino & Doyle-Portillo, 2009:63).

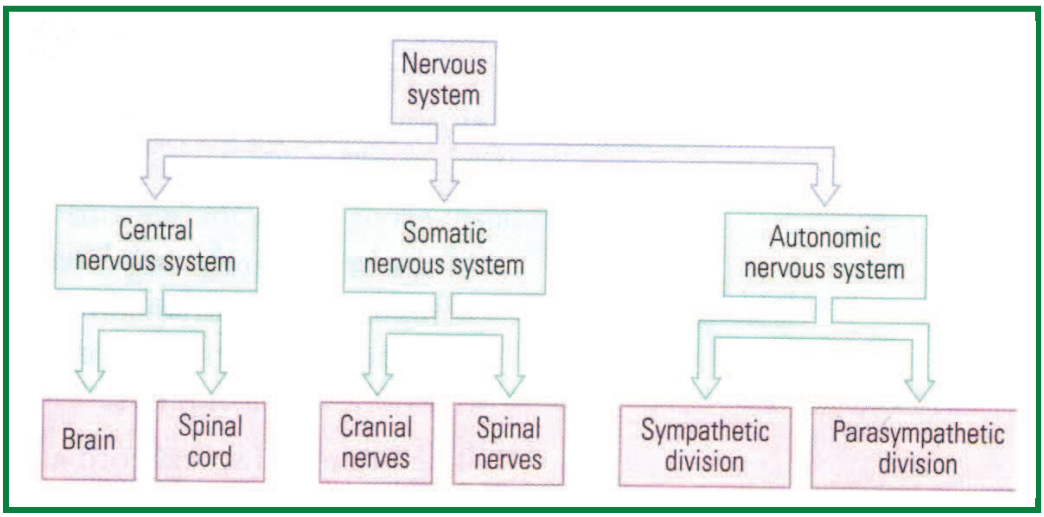

Figure 3.6 Functional Divisions of the Human Nervous System

(Kolb & Whishaw, 2009:55)

The ANS (see figure 3.6) balances the body's internal organs through calming (***parasympathetic***) nerves or "fight or flee" vigorous activity-arousing (***sympathetic***) nerves (Kolb & Whishaw, 2009:55; Pastorino & Doyle-Portillo, 2009:64). These antagonistic components are responsible for preserving a constant homeostatic internal environment (Majoviski & Breiger, 2009:69). Without the ANS, which regulates the internal organs and glands by connections through the SNS to the CNS, life would quickly cease (Kolb & Whishaw, 2009:65).

The ***brainstem*** (see figure 3.7) begins where the spinal cord enters the skull, and includes several regions: the medulla oblongata, the pons, the diencephalon, the midbrain, and the hindbrain (Baehr & Frotscher, 2012:3-45; Kolb & Whishaw, 2009:67; Semrud-Clikeman & Ellison, 2007:32). The brainstem produces more complex movements than does the spinal cord, but its overall plan is similar, being responsible for sensory functions and motor functions (Kolb & Whishaw, 2009:67). It harbours the centres of origin and termination of ten of the twelve cranial nerves (Baehr & Frotscher, 2012:3-45; Niewenhuys, Voogd & Van Huijzen, 2008:190). It is responsible for the neurons which control heartbeat, blood pressure, breathing and also the signals to swallow, laugh and sneeze. The function it fulfils is so fundamental that injury to the core of the brainstem results in death. Primitive reflexes are mediated at the level of the

brainstem, while most postural reflexes are controlled by the midbrain (Goddard, 2005:43) (see the discussion on reflexes later in this chapter).

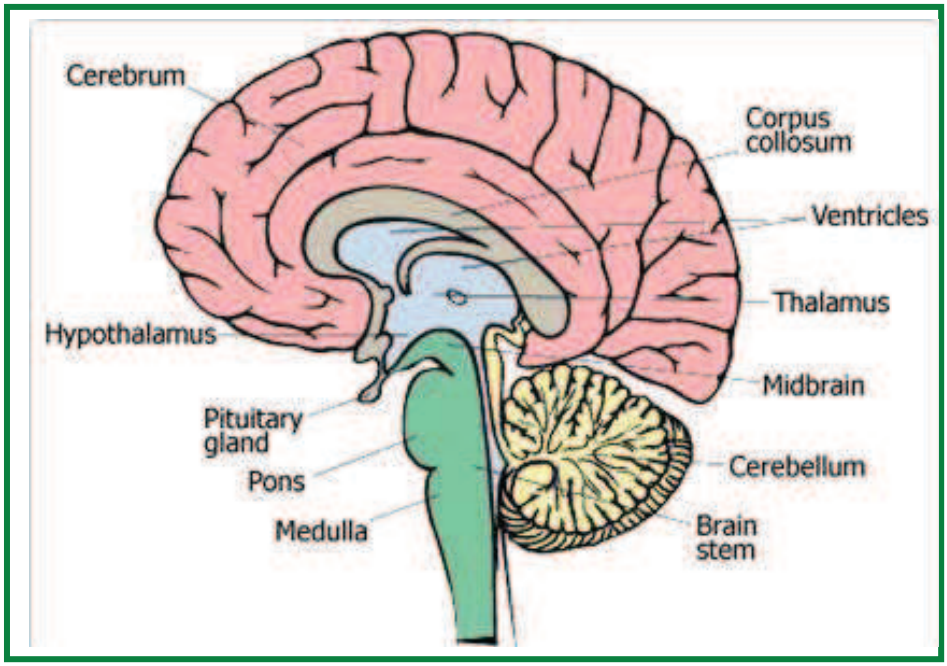

Figure 3.7 The Brain – Side View
(American Medical Association, 2011)

The most distinctive part of the hindbrain is the ***cerebellum*** (Kolb & Whishaw, 2009:67). It is connected to the brainstem, but is not part of it (Goddard, 2005:45). The cerebellum plays a role in coordinating and learning skilled movements. Thus damage to this part of the brain results in equilibrium problems, postural defects and impairments in skilled motor activity (Kolb & Whishaw, 2009:68). The basal ganglia and the cerebellum are involved in many aspects of planning and monitoring movements but have no outputs of their own to the spinal cord (Goddard, 2005:44). An enormous amount of integration occurs in the cerebellum (Majoviski & Breiger, 2009:73), and it governs people's every movement (Goddard, 2005:45). The cerebellum receives sensory information of where the limbs are in space and signals where muscles should be positioned (Semrud-Clikeman & Ellison, 2007:34) through action potentials from the skin, joints and primary endings of the neuro-muscular spindles (Goddard, 2005:46). The cerebellum receives information from the vestibular system (the semi-circular canals in the inner ear)

concerning orientation in space (Kolb & Whishaw, 2009:68; Semrud-Clikeman & Ellison, 2007:34), as well as from the eyes and the muscle joints of the lower limbs and trunk (Goddard, 2005:45). It is the centre for the smooth coordination of muscular responses, especially those involved with subconscious maintenance of normal posture (Majoviski & Breiger, 2009:74). Activities which at first need practice (such as learning to drive a car) should finally be absorbed into the automatic repertoire of the basal ganglia together with the cerebellum (Goddard, 2005:45). The cerebellum is predominantly involved in the learning stages of a new skill, but as a child becomes more proficient at a skill, less cerebellar activity is involved (Goddard, 2005:46). Ultimately, the cerebellum is responsible for regulating the postural reflexes and muscle tone (Goddard, 2005:45), may even be involved in affective responses (Majoviski & Breiger, 2009:74), and is a central organ for fine motor control (Baehr & Frotscher, 2012:4-73).

Projections of major cranial nerves occur at the level of the ***medulla oblongata*** (see figure 3.7), as well as at the crossing of the auditory and visual systems. The sensory and motor tracts also cross over into the opposite side of the brain at the medulla, so that sensory information and movement on the right side of the body are primarily controlled by the left hemisphere. Conversely, the left side of the body is controlled by the right hemisphere. The reticular activating system (RAS) comprises a major portion of the medulla (Semrud-Clikeman & Ellison, 2007:33) and works like the brain's own alarm clock (Goddard, 2005:43). The RAS controls sleeping and waking (Kolb & Whishaw, 2009:68) and plays an important part in maintaining consciousness, including waking alertness and the ability to pay attention (Goddard, 2005:43). Neuroscientists now recognise that the pons and the medulla also play a part in waking and sleeping, as well as in locomotion (Kolb & Whishaw, 2009:68).

The ***pons*** (between the medulla and midbrain and above the cerebellum) serves as a bridge across the right and left hemispheres. Major sensory and motor pathways move through the pons and enter into the higher cortical areas. In coordination with the cerebellum, the pons receives information concerning movements from the motor cortex and helps modulate movements. Information from the visual cortex is also received, and

serves to guide visually determined movements. Finally, a number of cranial nerves converge in the pons and transmit signals for swallowing and chewing (trigeminal nerve), facial muscle movement, the innervation of the eye muscles (abducens nerve), and hearing and equilibrium in the inner ear (Semrud-Clikeman & Ellison, 2007:33-34).

The ***midbrain*** serves as a major relay function for sensory-motor fibres, and several cranial nerves are located in the midbrain region (Semrud-Clikeman & Ellison, 2007:34). Massive amounts of sensory information from the eyes and ears are received; and visually-related and auditory-related behaviours are mediated. The brain's reward centre, which plays an important role in motivation and attending, is also found in the midbrain (Kolb & Whishaw, 2009:68).

The ***diencephalon*** borders the older and the newer parts of the brain and is located in the middle of the brain between the brainstem and the forebrain. It consists mainly of the three thalamic structures: the hypothalamus, the epithalamus and the thalamus (Baehr & Frotscher, 2012:4-88; Kolb & Whishaw, 2009:69). The diencephalon contains the major relay and integrative centres for all the sensory systems except smell (Semrud-Clikeman & Ellison, 2007:34). The ***hypothalamus*** (only 0.3% of the brain's weight) takes part in nearly all aspects of motivated behaviour (with connections to the limbic system), including feeding, sexual behaviour, sleeping, temperature regulation, emotional behaviour, movement, and, through its interactions with the pituitary gland, endocrine function (Kolb & Whishaw, 2009:69). The hypothalamus acts as the synthesiser of the hormones involved in temperature control, water balance, hunger and sexual behaviour, and coordinates vital bodily functions such as respiration, circulation and nutritional intake (Baehr & Frotscher, 2012:4-88). These hormones are then channelled into the pituitary gland where they are either stored or released into the bloodstream. Together with the hippocampus and amygdala, these two centres are labelled the seat of the limbic system. It is from the limbic system that feelings of passion, drive, fear, anger and grief are generated. The limbic system is also concerned with the laying down of memories, which may be one reason why children seem to learn better when they relate physically and emotionally to the learning material. It is also why

the memory of traumatic experiences of the past can rekindle the physical sensations of fear and agony associated with the original event (Goddard, 2005:44). The hypothalamus thus plays an important role in controlling the ANS (Semrud-Clikeman, 2007:34). The ***thalamus*** (largest structure in the diencephalon) projects to the cortex and relays (1) information from sensory systems to their appropriate targets; (2) information between cortical areas; and (3) information from other forebrain and brainstem regions. In short, almost all the information received by the cortex is first relayed through the thalamus (Kolb & Whishaw, 2009:69). The thalamus therefore acts as an important relay station for sensory and motor fibres. As all of the senses (except for smell) are filtered through the thalamus before they reach the specialised regions in the cortex, this structure plays a vital role in the ultimate interpretation of sensory stimuli (Goddard, 2005:43). The epithalamus's function is generally poorly understood; but one of its structures, the pineal gland, secretes the hormone melatonin, which influences daily and seasonal body rhythms. Another structure regulates hunger and thirst (Baehr & Frotscher, 2012:4-88; Kolb & Whishaw, 2009:69-70).

The entire adult brain and the nervous system are made up of basic cell types referred to as neurons and glia. The next section offers an overview on the vital functioning of these cells.

3.3.1.3 Neuron Cells and Myelination

Figure 3.8 shows the three basic parts of a ***neuron***. The core region is called the cell body, the branching extensions are called dendrites, and the main "root" is called the axon. The main purpose of the dendrites and axon are to extend the surface area of the neuron cell. The ***dendrites*** receive incoming signals from other neurons and conduct nerve impulses toward the cell body (Ayres, 2005:30; Kolb & Whishaw, 2009:20; Pastorino & Doyle-Portilla, 2009:49; Semrud-Clikeman & Ellison, 2007:26). The axon grows out of the cell body and carries signals away from the cell body. The ***axon*** represents a long tail-like structure, of which the length is dependent on the location in the NS (Pastorino & Doyle-Portilla, 2009:49). It is remarkable to note that the length of an axon in the brain might be as short as one millimetre or less, while the axons that

extend down the legs can be almost a metre in length (Pastorino & Doyle-Portilla, 2009:50).The rate of axon development is extremely rapid, in the order of 1mm per day (Kolb & Fantie, 2009:24).

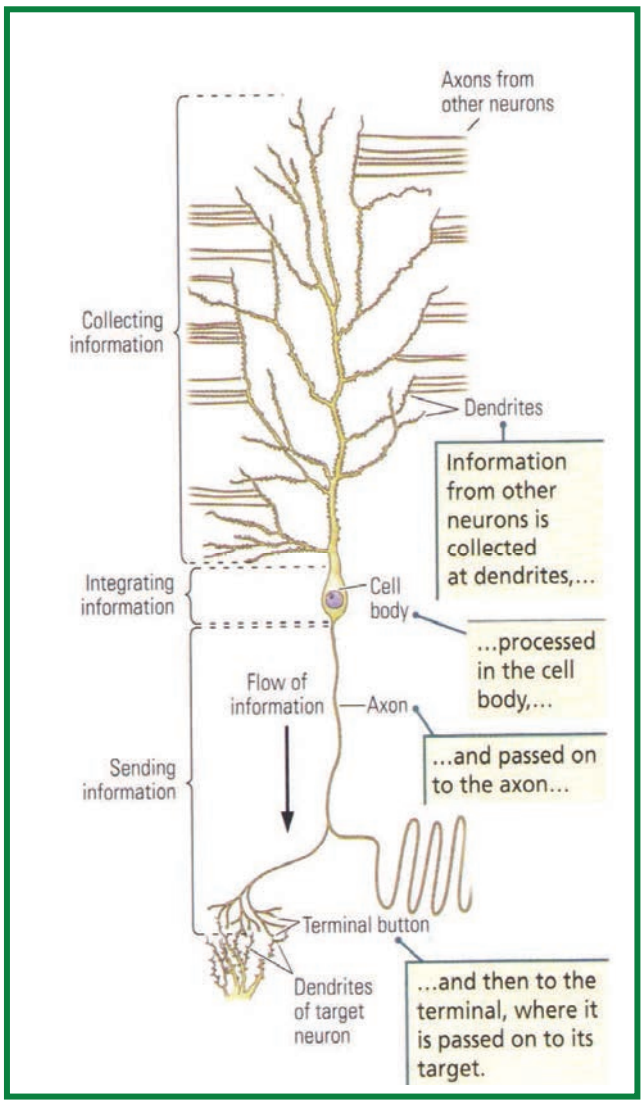

Figure 3.8 The Neuron

(Kolb & Whishaw, 2009:84)

Dendrites begin as simple, individual processes protruding from the cell body. Later, they develop increasingly complex extensions that look much like the branches of trees visible in the winter months. Although dendritic development begins prenatally in humans, it continues for a long time after birth (Kolb & Fantie, 2009:24; Kolb & Whishaw, 2009:660). In contrast to the development of axons, dendritic development usually commences after the cell reaches its final position in the cortex and proceeds at a fairly

slow rate (Kolb & Fantie, 2009:24). At birth, the connections to the superficial layers of the cortex are only barely made. In the first few years of life the developing child must form millions of new connections between nerve cells, which will provide a network of communication or neural circuitry of enormous complexity upon which future behaviour and learning will be based (Goddard, 2005:42). With continued stimulation, the brain becomes composed of a complex network of neurons (Kokot, 2010a:21). An illustration of this concept is given in figure 3.9, where the remarkable growth rate of the neural network can be seen.

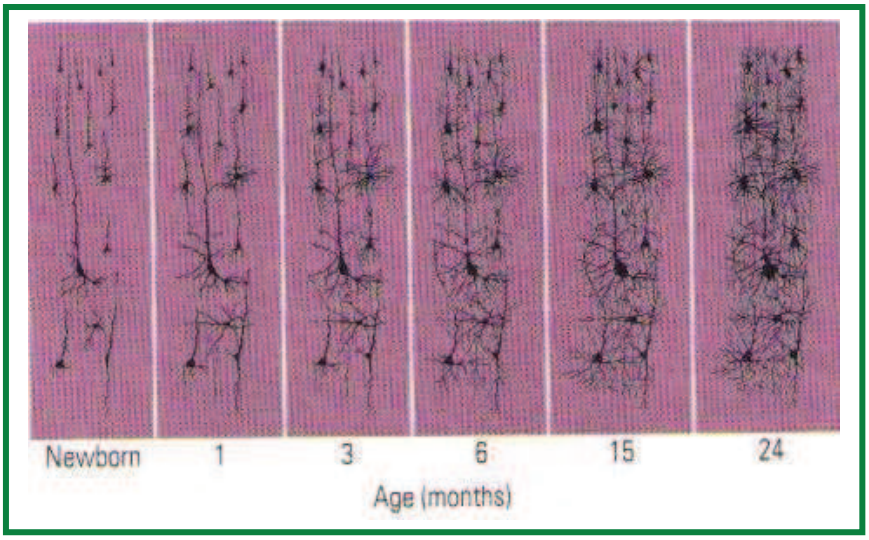

Figure 3.9 Dendrite Density Development

(Kolb & Whishaw, 2009:660)

Neurons differ chiefly in overall size, in the length and branching of their axons, and in the complexity of their dendritic processes (Kolb & Whishaw, 2009:57; Sigelman & Rider, 2009:6). Neurons enable us to acquire information, process it, and act on it. They use a sophisticated communication system to conduct the signals that allow people to control their bodies (Pastorino & Doyle-Portillo, 2009:47).

Synapses are the connective spaces between cells (see figure 3.10) and link the axon of one neuron to the dendrites, the cell body, the axons or established synapses of other cells (Ayres, 2005:35; Kolb & Fantie, 2009:21; Sigelman & Rider, 2009:125; Shaffer & Kipp, 2010:204). The onset of synaptogenesis is sudden and the presence of synapses in a particular area is remarkably rapid although neurons may be juxtaposed for days

before they make actual synaptic connections (Kolb & Fantie 2009:25). When individual cells are activated at the same time, they establish connecting synapses or strengthen existing ones and thus become a functional unit (Kolb & Whishaw, 2009:23; Sigelman & Rider, 2009:125). The neurons work together to transmit electrical and chemical signals across many trillions of synapses (Shaffer & Kipp, 2010:203).

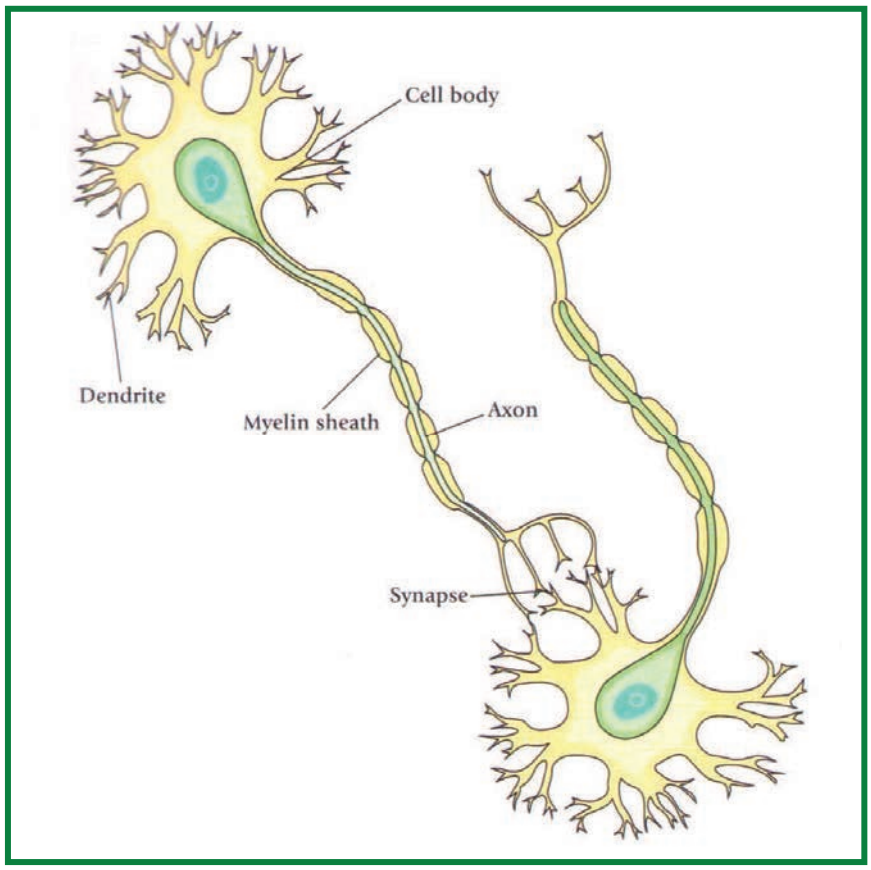

Figure 3.10 Two Neurons Forming a Synapse
(Shaffer & Kipp, 2010:204)

Gale, O'Callaghan, Godfrey, Law and Martyn (2004) state that synaptic density in both the cerebral and cerebellar cortices increases until early adult life. A fascinating fact is that the average infant has far more neurons and neural connections than adults do. Neurons that successfully interconnect with other neurons crowd out those that do not, so that about half the neurons produced early in life also die early. Synapses grow rapidly (around 40 000 per second) in the cortex, beginning before birth and continuing until approximately two years of age. The next phase is characterised by an initial

plateau in synapse number followed by rapid elimination of synapses that continues through puberty. Synapses may be lost at a rate of 100 000 per second during adolescence. The reduction in synapses is dramatic if one considers that they may fall to 50% of the number present at age two. It is interesting that decreased synaptic density coincides with increased cognitive skill. It is almost certain that the process involved in the reduction of synaptic density often denotes some sort of qualitative refinement. The last phase is characterised by another plateau in synapse number through middle age, followed by a drop in senescence (advanced old age) (Kolb & Fantie, 2009:25; Kolb & Whishaw, 2009:662).

Surviving neurons form hundreds of synapses, many of which will disappear if the neuron is not properly stimulated (Ayres, 2005:37; Shaffer & Kipp, 2010:204). Synapses are formed both by ***experience-expectant*** and by ***experience-dependent*** mechanisms. The former refers to synaptic development that depends on the presence of certain sensory experiences for the organisation of cortical circuits. The latter refers to the generation of synapses that are unique to an individual organism, because they are produced in response to experiences that are unique and personal (Kolb & Fantie, 2009:26; Kolb & Whishaw, 2009:662-663).

According to Stiles (2000), a common claim in the earlier literature was that the developing brain is plastic. This means that during development the brain is capable of reorganising patterns of connections in ways that the mature brain cannot. However, more recent research suggests that the capacity for dynamic change is retained in the adult neural system (Sigelman & Rider, 2009:127). Stiles (2000) goes on to define ***plasticity*** as:

- Some dynamic feature of the neural system, which brings about change at structural or functional level (reference to process)
- Plastic systems recruit new or different resources in response to some external demand (reference to adaptation)
- A systematic interaction of structural features and input from the environment (reference to organisation)

Plasticity thus refers to the fact that the neurons are highly responsive to the effects of experience. Brodal (2004:103) and Cheatum and Hammond (2000:34) explain that plasticity is the nervous system's ability to adapt structurally and functionally to altered demands. As no one has such a broad range of experiences, so much of one's neural circuitry remains idle. It is presumed that neurons and synapses that are most often stimulated continue to function, whilst surviving neurons that are stimulated less often lose their synapses. This process is referred to as ***synaptic pruning***, and refers to cells standing in reserve to compensate for brain injuries or to support new skills. One can therefore foster neural development of an immature brain by exposing participants to enriched environments that provide a wide variety of stimulation (Kolb & Whishaw, 2009:686; Shaffer & Kipp, 2010:204-205). In cases where a neurological pathway has been interrupted through injury, stroke, or disease, some connections can be restored or new ones can be created. The creation of a new pathway is referred to as ***sprouting***, much like a branch of a tree. Sprouting, in the brain of a child, is a direct result of the demands of the environment and the child's responses to these demands (Cheatum & Hammond, 2000:35). This is a very promising consideration, as it suggests that a balanced programme consisting of a broad range of stimulation can benefit brain development, and assist in the formation of new connections. Cheatum and Hammond (2000:37) emphasise that plasticity depends on both having a stimulating environment and persistently repeating the activities in order to form the new neurological pathways.

There has been controversy over ***neurogenesis*** in the adult brain. Until recently it was thought that neurogenesis in the mammalian brain ends in the period just after birth. Ongoing adult neurogenesis was only convincingly demonstrated in two brain areas, namely, the olfactory system and the dentate gyrus of the hippocampus (Gage & Van Praag, 2002:110) However, there is more recent consensus that neurogenesis continues in three regions (the hippocampus, olfactory bulb and the substantia nigra) and that new nerve cells are continually produced throughout life. Although neurogenesis has also been reported in the cortex and amygdala, these findings have been difficult to replicate consistently (Kolb & Fantie, 2009:24; Niewenhuys, Voogd & Van Huijzen, 2008:22). Animal studies indicate that factors such as stress and

depression may reduce the birth of new neurons, and suggest that neurogenesis decreases with ageing. An opposing view is that environmental and behaviour interventions can enhance neurogenesis (Gage & Van Praag, 2002:113). Several areas of interest emerge when considering the therapeutic potential for neurogenesis. One includes a strategy that takes advantage of the ability of adult brain stem cells to be isolated and induced to divide, and used for cellular transplantation to replace cells that have died because of injury or disease (Gage & Van Praag, 2002:115).

In a human study, head circumference was assessed in 221 children at 18 weeks gestation, at birth, at nine months, and again at nine years of age (Gale *et al*., 2004). Head circumference (a rough indicator of brain size) is a measurement regarded by paediatricians as an indication of normal brain development. Increase in size is due to an increase in cellular density, cell size and myelination, but not an increase in cell number (Rossi, 2005:21). The head circumferences of children from high socioeconomic backgrounds, and of those whose mothers had earned college degrees, were significantly larger than those children from low socioeconomic homes and whose mothers had no degrees. There was a strong statistical correlation between measures of postnatal head growth and intelligence scores (IQ) of the children at nine years of age. Interestingly, verbal IQ was associated with head growth between nine months and nine years of age, while performance IQ was more strongly associated with head growth in the first nine months of life (Gale *et al*., 2004). It is important to note that most of the parents in the study's sample were from a very low socio-economic background, had no tertiary education and were unemployed, and that these characteristics might have impacted negatively on their children's cellular density in the brain.

Another type of cell that plays a supporting role in the nervous system is ***glial cells***. They outnumber neurons by about ten to one and unlike neurons, are replaced constantly throughout life (Evans-Martin, 2010:17-18). In contrast to neurons, which have only recently been shown to grow continually in certain restricted brain areas, glial cells continue to proliferate throughout life (Kolb & Fantie, 2009:26). Glial cells surround neurons and provide structural support to hold neurons in place. They also offer

supporting functions such as waste removal. Glial cells further nourish the neurons by contacting nearby blood vessels and transporting nutrients from the bloodstream, regulate the signals that neurons send to one another, and eventually enclose them in insulating sheaths of a waxy, whitish, fatty substance called myelin (Evans-Martin, 2010:18; Kolb & Fantie, 2009:21; Kolb & Whishaw, 2009:19; Pastorino & Doyle-Portillo, 2009:48; Shaffer & Kipp, 2010:204). The myelin gives the axons a white appearance (Semrud-Clikeman & Ellison, 2007:27).

Myelin is the covering of glial extensions that wrap around the axon of the neuron in as many as a hundred layers (Evans-Martin, 2010:18). This myelin sheath acts as an insulator to speed up the transmission of neural impulses between cells, allowing the brain to communicate more efficiently with different parts of the body, and prevents interference from the electrochemical activity of surrounding neurons (Pastorino & Doyle-Portillo, 2009:48; Sigelman & Rider, 2009:125; Kokot, 2010a:18).

At the outset, the axon remains free of myelin, which is only laid down once the neuron begins to receive impulses. The more the neuron is used, the more myelin is produced in thick layers all around the axon (Kokot, 2010a:19). Although the stimulation received through the sensory receptors is important, the vital movement that the body makes as a result of reflexes is just as important (Kokot, 2010a:30). An explanation of reflexes and a thorough discussion will follow later. Myelinisation follows a specific chronological sequence that is consistent with the maturation of the NS and is a process that is closely related to the functional capacity of the neurons (Majoviski & Breiger, 2009:76). It is only when brain neurons have been myelinated that we refer to them as having developed. Developed areas of the brain are those areas that have myelinated axons (Kokot, 2010a:20). In contrast to other aspects of cortical development, myelin only appears at a time when cellular proliferation and migration are nearly complete (Kolb & Fantie, 2009:27). At birth, the pathways between the sense organs and the brain are reasonably well myelinated (Shaffer & Kipp, 2010:205-206). The cerebellum grows at a faster rate than the cortex and completes a major period of myelination by four years of age. After this, the cerebellum continues to develop up to 15 years of age and beyond,

albeit at a slower rate. The cerebellum learns by doing. Repetition improves performance as a result of synaptic connections being repeatedly fired and the involved neurons adapting their function to become more efficient (Goddard, 2005:46). Motor neurons of the cranial nerves show myelination patterns before their sensory counterparts. Myelination of axons of the cerebral cortex continues well into adulthood (Majoviski & Breiger, 2009:76), with myelination in the frontal lobes only completed well into the third decade of life (Semrud-Clikeman & Ellison, 2007:27).

The myelin sheath is made up of a large percentage of the essential fatty acid (EFA) known as Omega-3 (Kokot, 2010a:18). This is one of the polyunsaturated fatty acids (PUFAs) that cannot be synthesised by humans and must be obtained from the diet. Once obtain through one's diet, both linoleic acid (Omega-6) and alpha-linolenic acid (Omega-3) can be converted into the more complex fatty acids needed for optimal brain function and structure (DGLA and AA from the Omega-6 series, and EPA and DHA from the Omega-3 series). Structurally, AA and Docosahexaenoic acid (DHA) are key components of neuronal membranes and severe deficits may have permanent effects if they occur during critical periods of neural development. AA is vital for brain growth, while DHA is particularly concentrated in highly active sites such as synapses and photoreceptors, and is essential for normal visual and cognitive development (Richardson, 2001). Green leafy vegetables and some nuts and seeds can provide Omega-3 EFA (alpha-linolenic acid). However, it is the EPA and DHA that the brain needs, and given that the conversion may be difficult, a direct supply is preferable. Oily fish and seafood are the major food sources of EPA and DHA, and supplements are often the only realistic option when these are not freely available. Adequate supplies of Omega-6 are also vital, although Omega-3 is likely to be more important as early studies of evening primrose oil (EPO, which is an Omega-6 EFA) alone indicated little benefit for the central problems of learning and behaviour (Richardson, 2001).

More specifically, DHA is important for the development of the CNS and the structure of the neuronal membranes, while EPA is essential for the moment-by-moment regulation of brain function (Richardson, 2001). Harris (2006:98) and Kokot (2010a:18) suggest

that a deficiency of Omega-3 fatty acids in the diet of pregnant mothers or young children has implications for the structure and functioning of the NS and may play an important role in brain development and function.

One of the first studies to examine the long-term effects on children of maternal supplementation with very long chain PUFAs showed that four year-old children have higher mental processing scores when the mothers' diets were supplemented with very long chain Omega-3 EFA during pregnancy and lactation, compared with children of mothers who were supplemented with long-chain Omega-6 EFA. The results suggest that maternal intake of DHA during pregnancy is important for children's mental development. A significant correlation between head circumference and mental processing skills was also noted in this study (Helland, Smith, Saarem, Saugstad & Drevon, 2003).

A study on primary school children in the rural areas of Lebowa, South Africa, showed a high prevalence of under-nutrition, particularly associated with an imbalance of dietary fatty acid intake (Tichelaar, Steyn, Badenhorst, Nel, Smuts, Van Jaarsveld & Benadé, 1994). A doctoral study in the Northern Cape Province of South Africa showed that a sandwich spread high in essential fatty acids can improve the learning ability and memory of children between the ages of six and nine in a low socioeconomic area (Dalton, 2006:4, 66, 117, 170). The scope of this study does not allow for a thorough discussion on nutrition and the effect thereof on brain and cognitive development; neither does it extend to a literature review on the nutritional status of children in QwaQwa. However, it is relevant to note that nutrition plays a vital role in the normal growth and development of a child, and that South Africa has a problem of chronic malnutrition in all provinces. Rural areas appear to be more affected than urban areas (Faber & Wenhold, 2007). If a child does not get enough EFAs through their diet or supplements, the myelin sheath protecting the axons of billions of neurons may not develop adequately, and as a result may compromise the optimal and effective functioning of the brain and nervous system (ILT, 2010a). Finally, it should be noted that factors other than EFAs should always be considered in the nutritional management of

behavioural and learning difficulties. An adequate supply of other essential micronutrients is crucial, and many – such as zinc – are likely to have interactive effects on fatty acid metabolism (Arnold, Pinkham & Votolato, 2000).

As we turn to a consideration of NS chemicals, called ***neurotransmitters***, it is salient to note that electrical conduction through the body relates to information flow in neurons (Kolb & Whishaw, 2009:21). Information that travels through a neuron begins on the dendrites and travels along the axon to the terminals (see figure 3.8). The flow of information consists of discrete electrical impulses (see figure 3.11).

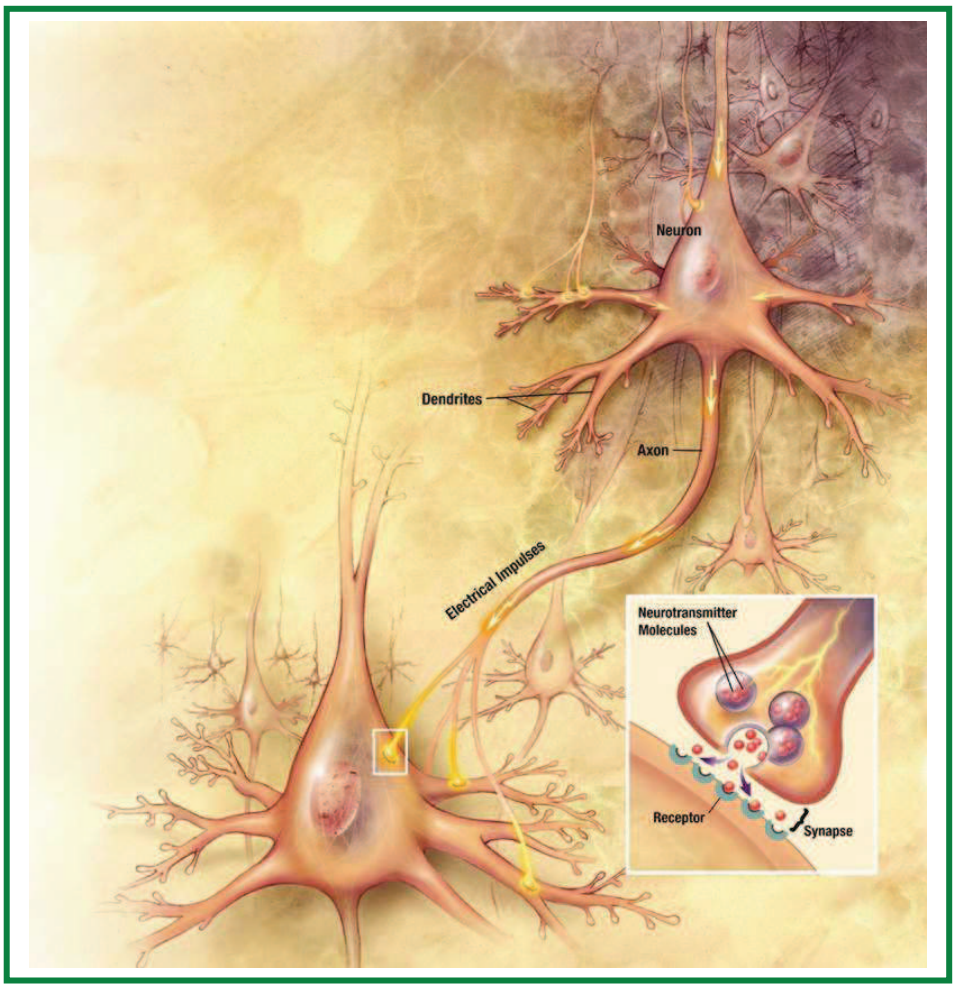

Figure 3.11 Electrical Impulses and Neurotransmitters

(St. Petersburg Centre for Interdisciplinary Neuroscience, 2009)

As each impulse reaches the terminal buttons, they release one or more chemicals,

called neurotransmitters (Kolb & Whishaw, 2009:84). Neurotransmitters are produced by cells in the terminal buds of axons (Kokot, 2010a:18) and allow areas of the brain to communicate with one another (Schmidt, 2001:20). They drift across the synapse to interact with the neighbouring nerve. The neurotransmitters carry messages across the synapse to influence the electrical activity of the receiving cell, and so pass the message along (Kolb & Whishaw, 2009:84; Pastorino & Doyle-Portilla, 2009:50).

Here again, fatty acids play a critical role. The delicate membrane of the synapse has a higher concentration of DHA than almost any tissue in the body. If this is not the case, the neurons do not fire with normal efficiency. While the neurotransmitters are themselves not fats, their ability to land in the right spot and trigger their action may significantly depend upon fatty acids. In this way, fatty acids have a profound effect on the efficiency of the neurotransmitter system (Schmidt, 2001:20-21; Schmidt, 2006:46). Dietary fat can therefore influence nerve communication, and may influence mood, behaviour, learning, and even our ability to move our bodies (Schmidt, 2001:22; Schmidt, 2006:22). Hibbeln and Makino (2002:79) reported that an alteration in the Omega-3 fatty acid composition in animal diets leads to an alteration in neurotransmitter concentrations. Certain foods contain starting materials for some neurotransmitters, and a deficiency in certain precursors renders the brain incapable of producing certain neurotransmitters. Vitamins, minerals, proteins and fatty acids all aid or protect the manufacture of certain neurotransmitters. If a person's diet does not contain adequate amounts of these helpers or protectors, certain neurotransmitters are not made or stored in the right amounts. The result may be negative changes to moods, thinking, learning and other life functions (Nickelsen & Anderson, 2006:341-343).

A very exciting discovery is the ***mirror neuron***, a type of nerve cell found in the brain. This specific neuron not only discharges when a person makes a movement, but also discharges in the same way when a person see someone else making the same movement (Kolb & Whishaw, 2009:232). Mirror neurons have been identified as those that respond both when a person moves a specific finger, and when they watch someone else move the same finger (Kalat, 2009:237). These special neurons encode

a complete action and the representations can be used to both imitate and understand the meaning of others' actions. In humans, mirror neurons are found largely in the left hemisphere (Kalat, 2009:237; Kolb & Whishaw, 2009:232-233). Similar mirror neurons in the language regions of the frontal cortex are likely responsible for the mimicking of sounds and words by children (Kolb & Whishaw, 2009:534). It has even been suggested that mirror neurons may play a role in not only understanding the actions of others, but perhaps even their intentions (Kolb & Whishaw, 2009:582). Iacoboni (2009) goes on to explain that congruent mirror neurons (defined as neurons that fire during the observation of an action achieving the same goal or logically related to the action they code motorically) support cooperative behaviour among people by providing a flexible coding of actions of self and others. This flexibility is an important property for successful social interactions, as people perform coordinated, cooperative and complementary actions. Mirror neurons also code facial actions, in particular the ingestive and communicative actions of the mouth. Mirror neurons may thus facilitate our understanding of others' emotions, because the face is the body part that we use most often to express our emotions.

In summary, through the workings of the NS, we are able to take in information from everything in our world through the sensory systems of touch, sound, sight, temperature, taste and smell, and know where we are positioned on earth (against gravity and in relation to everything else). All the information received via the NS is processed in the brain. Once the brain has attached meaning to the information, the brain is able to direct the body to act in response to the stimuli. The response is more often than not in the form of one or another movement – for this reason we use the term sensory-motor system (Kokot, 2010a:13). Just like the brain and NS, the sensory-motor system and all its subsystems also follow a developmental hierarchy. Touch develops first, closely followed by taste and smell, and then the very important vestibular system, and so on (Van der Westhuizen, 2007:115). The sensory-motor system, and its developmental hierarchy, are discussed in chapter four.

The discussion now continues with the focus on locomotor development.

3.3.2 Locomotor Development

When compared to other species, human beings' physical and motor development is a long and drawn-out process (Keenan & Evans, 2009:88). Meggitt (2006:2) refers to physical development as the way in which the body increases in skill and becomes more complex in its performance. Sigelman and Rider (2009:3) elaborate that physical development refers to the growth of the body and organs, the functioning of physiological systems and the physical signs of aging. It is not simply a set of maturational or biological processes, but is also largely influenced by the environmental context (Slentz & Krogh, 2001:60). Factors such as cultural practices, nutrition, and as opportunities to experience and play an important role in physical development (Nevid, 2007:348; Keenan & Evans, 2009:88).

Locomotor development refers to changes in children's mastery of mobility. The developmental sequence begins with natural and unplanned arm and leg movements during the foetal and newborn periods, followed by rolling, crawling and other idiosyncratic forms of prone (flat or horizontal) progression through the first year of life. Babies then starts pulling themselves up to stand, later balancing upright, then walking at the end of the first year of life; and finally mastering running, jumping, and more sophisticated forms of mobility (Marin, Weise & Adolph, 2000:355). Marin *et al*. (2000:356) state that the order and appearance of each form of locomotion stems from child-rearing practices distinctive to each culture, the infant's body proportions and muscle strength, as well as the infant's temperament and drive to go somewhere. While locomotor milestones develop most rapidly in the first two years of life, the development of locomotor skills never stops. Humans are constantly faced with new tasks that require new locomotor abilities, from tasks that require fine motor coordination to learning how to play a new sport (Marin *et al*., 2000:357-358).

In contrast to the extremely rapid growth during the first years of life, the preschool and middle school years are characterised by a more stable, slower increase in height and weight towards adolescence (Keenan & Evans, 2009:93).

Figure 3.12 provides a brief overview of the phases of motor development across the lifespan. A discussion of the phases of motor behaviour applicable to the study sample and to an understanding of the selected neurodevelopmental movement programme (refer to chapter four) follows, with a focus on the reflexive, rudimentary and fundamental movement phases.

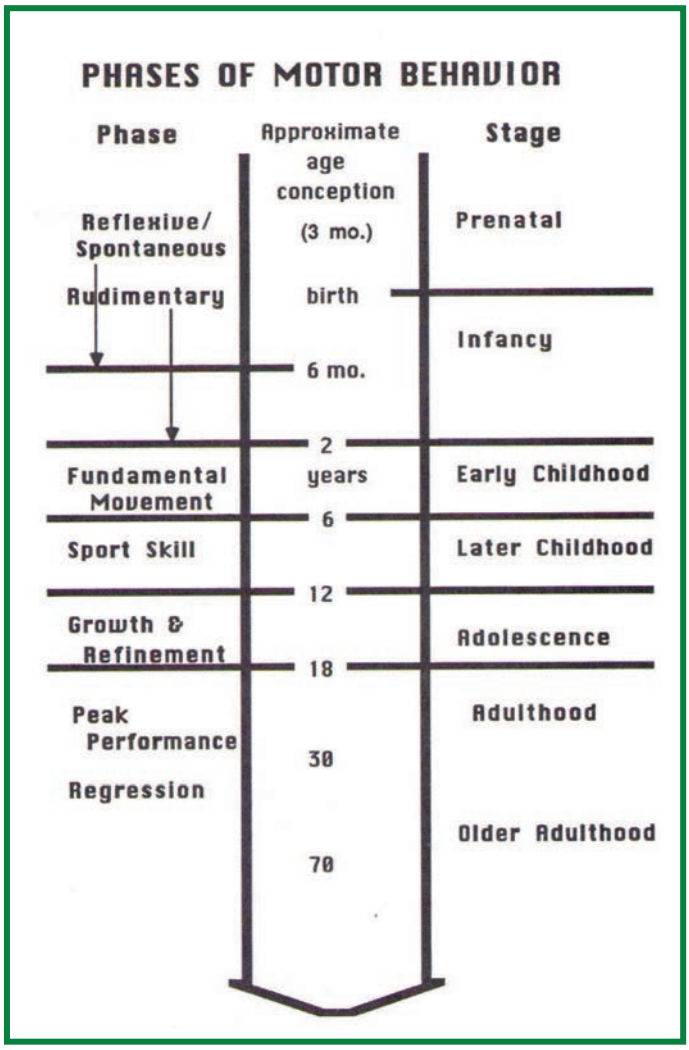

Figure 3.12 Phases of Motor Behaviour

(Gabbard, 1992:12)

3.3.2.1 The Reflexive / Spontaneous Movement Phase

Motor development does not begin at the time of birth; rather it has its origins in the prenatal period in the form of motor reflexes (Gabbard, 1992:221; Nevid, 2007:348). Motor behaviour begins at about the third foetal month and continues after birth into the

first year of life (Gabbard, 1992:11). Initially, newborn babies have little control over their body and all essential movements made are reflexes. Reflexes are involuntary (not within conscious control) movements dependent on spinal-cord functions; and are automatic responses to particular stimuli such as sound, light, touch, or body position (Gabbard, 1992:221; Kokot, 2010a:30; Meggitt, 2006:8; Nevid, 2007:348; Kolb & Whishaw, 2009:65).

Primitive reflexes are controlled primarily by the lower brain centres (subcortical or primitive areas) and emulate the relative immaturity of the NS (Gabbard, 1992:221, 223). These reflexes are present at birth, are hard-wired into the brainstem and are inhibited by higher centres in the developing brain in approximately the first six months of postnatal life (Goddard, 2009:3, 32). During the first six months to one year, babies exhibit many reflexes while the neuromuscular system matures. Goddard (2009:3) explains that primitive reflexes start a gradual process of inhibition by higher centres in the brain as neurological connections to these higher centres develop. Motor development only occurs once children gain cortical (higher brain centre) control over the movements of their bodies. As the cerebral cortex matures, most of these temporary primitive reflexes gradually become inhibited and phased out as voluntary motor behaviour takes over (Shaffer & Kipp, 2010:205). ***Postural reflexes*** then enter the infant's repertoire and support the child's ability to react to gravitational forces and changes in equilibrium to maintain posture and balance (Gabbard, 1992:11, 221, 223; Goddard, 2009:6). Postural reflexes only develop after birth and take up to three-and-a-half years to fully develop (Goddard, 2009:3, 32).

Reflexes are very important. More specifically, they play a role in stimulating the CNS and muscles, developing and strengthening the neurological pathways, supporting nerve myelination, and infant survival (e.g., sucking). They may be used as a diagnostic tool for assessing neurological maturity (Gabbard, 1992:221; Goddard, 2009:6). According to the Centre for Integrated Learning Therapy (ILT, 2007:12-13), the reflex structure provides the correct blueprint for a complex network of wiring from one system in the body to another. If this is disrupted, then subsequent motor and sensory functions may

be affected, altering the way the messages will travel in the body. Goddard (2009:5) adds that this immaturity in the functioning of the CNS can interfere with optimal cortical functioning.

De Jager (2006:50) believes that most reflexes are specifically 'designed' to have a limited lifespan. She adds that each primitive reflex is supposed to disappear once its role in developing the CNS is completed. This should happen to allow the higher order centers (cortical areas) of the brain to take control. Kokot (2010a:31) goes on to explain that each reflex appears at a certain time, completes its purpose and is then inhibited by developing higher areas of the brain (integrated into the brain). Reflexes are the movement patterns that help babies reach their milestones of rolling, sitting, crawling and walking. Each of these milestones is a sign that the brain is developing higher levels, enabling these functions (Kokot, 2010a:31). The inhibition of reflexes occurs when the first function ceases through the development of another function. The first function becomes integrated in the second, and the suppression of a reflex frequently correlates with the acquisition of a new skill (Van der Westhuizen, 2007:101). Nevid (2007:348) agrees and elaborates that the presence and later disappearance of particular reflexes at expected periods of time are taken as signs of normal neurological development. The muscles that move with each reflex cause neural pathways to be activated, which in turn lay down more myelin and sprout more dendrites and axon terminals (Kokot, 2010a:32).

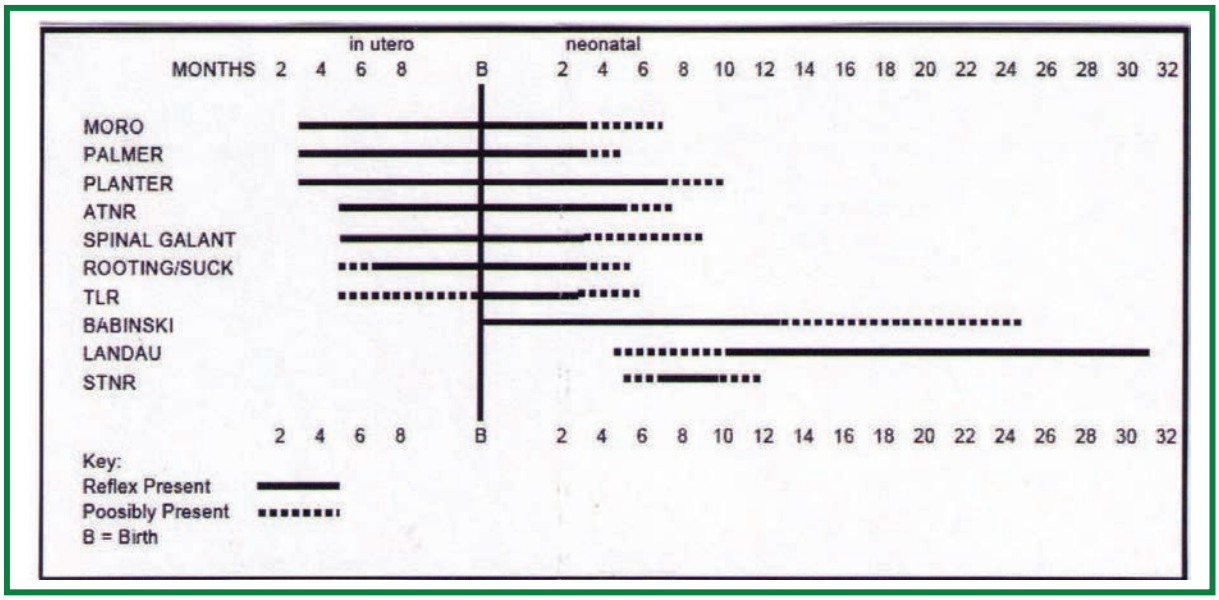

Figure 3.13 Primitive Reflex Profile

(Goddard, 1996:3)

Figure 3.13 traces the emergence and inhibition of some of the primitive reflexes. Van der Westhuizen (2007:101) notes that the knowledge of reflex chronology and normal child development may be combined to predict which later skills may have been impaired as a direct result of retained primitive reflexes. A child's profile of aberrant reflexes (continued presence of primitive reflexes) may therefore provide clues as to what is actively hindering the mastery of later skills.

Goddard (2005:2; 2009:4) describes ***neurodevelopmental delay*** as the continued presence of a cluster of primitive reflexes (aberrant reflexes) beyond the age of six months, together with absent or underdeveloped postural reflexes above the age of three-and-a-half years. Rarely will a single aberrant reflex by itself indicate neurodevelopmental delay. It is only when a cluster exists that neurodevelopmental delay is present (Goddard, 2005:116). More recently, Goddard (2011:189), has referred to this delay as ***neuro-motor immaturity***. For clarity's sake the researcher will use the former term throughout this study to refer to this picture of developmental delay. The presence or absence of primitive and postural reflexes at key stages in a child's development therefore provides a glimpse into the structural and functional integrity of

the hierarchy of the brain. Primitive reflexes are thus important indicators of the health of the CNS (Meggitt, 2006:8; Goddard, 2009:5). If primitive reflexes thus persist beyond an expected time, it may not only indicate a delay in development (Meggitt, 2006:8), but also be diagnostic of immaturity in the functioning of the CNS, which can interfere with optimal cortical functioning (Goddard, 2009:5), and will influence the development and control of posture, balance, and motor skills (Goddard, 2009:4). When aberrant primitive reflexes remain, the fundamental tools vital for learning will be ineffective despite adequate intellectual ability. Cheatum and Hammond (2000:59) state that it is not uncommon among elementary school children with learning and behaviour problems to still present with primitive reflexes. It appears as if later skills, instead of becoming automatic, may only be mastered through continuous conscious effort. Postural reflexes are mediated from the level of the midbrain, and their development thus signifies the active involvement of higher brain structures over brainstem activity. The development of postural reflexes is thus a sign of increased CNS maturity (Van der Westhuizen, 2007:100-101). Goddard (2009:5) adds that when the CNS is functioning well, the cortex is free to concentrate on higher functions being involved in intention and motor planning.

The difficulties associated with neurodevelopmental delay are not confined to the childhood years. As a child grows up the NS continues to develop and change. If problems related to aberrant primitive reflexes are not corrected during childhood, the associated problems tend to grow up with that child, like traits woven into the fabric of the personality. Abnormal primitive and postural weaknesses represent a structural weakness in the functioning of the CNS and can continue to undermine performance and diminish resilience to certain types of stress later in life. This may show itself in numerous ways, such as a low tolerance threshold for stress, anxiety or phobias (Goddard, 2009:271).

With the above context as background, an understanding of aberrant reflexes is not only important to indicate neurodevelopmental delay, but also provides valuable insight into a possible therapeutic intervention programme to address the neurodevelopmental delay.

This belief rests on the observation that all human babies make certain stereotyped movements during the first year of life. These movements not only facilitate inhibition of the primitive reflex, but also the emergence of a postural reflex (Goddard, 2009:359). The detection and analysis of primitive and postural reflexes can therefore be used as a tool to assess the level of remediation required by a child, as it indicates the developmental stage a child has reached (Goddard, 1996:86). Van der Westhuizen (2007:102) suggests that in presenting the exact stereotypical movement, the natural inhibitor may be triggered and the reflex repressed as a result. By the selection and daily implementation of movements put together in a developmental sequence (Goddard, 2009:359), it is thus possible to give the brain a so-called 'second chance' to register the reflex inhibitory movement patterns (Van der Westhuizen, 2007:102). Such movements are based upon a detailed knowledge of reflex chronology and normal child development (Goddard, 2005:3). Jordan-Black (2005:101) and McPhillips, Hepper and Mulhern (2000:537) researched the effects of programmes aimed at replicating primary reflex movements on children with reading and/or mathematics difficulties. Both studies found that such programmes had a positive effect on children's learning.

Rosen and Joffee (1995:501) noted that an aberrant ***asymmetrical tonic neck reflex (ATNR)*** and an ***aberrant symmetrical tonic neck reflex (STNR)*** most notably affected the performance of motor skills with deaf-blind children. The ATNR is noticed when the child's head is turned towards one side, the arm and leg on that side extended or straightened, whilst the opposite arm and leg flexed or bent. The STNR is noticed when the child's neck extends, and then results in the child's arms extending and the legs flexing / bending. When the neck bends, the arms bend and the legs extend.

Depending on the degree of aberrant reflex activity, this poor organisation of nerve fibres may affect one or all areas of functioning. Van der Westhuizen (2007:100) explains that it may affect not only gross and fine muscle coordination, but also sensory perception (registering of sensory information in the brain), cognition (interpretation and understanding of that information) and avenues of expression. We may therefore conclude that a thorough understanding of reflexes is important in considering the

implementation of a neurodevelopmental intervention as well as selecting activities in such a programme to foster the integration of aberrant reflexes. The following section examines gross and fine motor skills.

3.3.2.2 The Rudimentary and Fundamental Movement Phase

The development of motor skills follows the sequence: reflex motor, gross motor and fine motor. Gross motor skill development thus depends on the successful development of reflex motor skills, while the development of fine motor skills depends on good gross motor development. Gross and fine motor skills are especially important during the preschool stage (Louw *et al*., 1998:236 – 237). Gross motor skills require the effective use of large muscle groups, for example, the muscles that children will use when they start walking or climbing a tree. Fine motor skills refer to the use of the small muscles in the hands and fingers, for example, the muscles that children use when they use a pair of scissors (Louw *et al*., 1998:237; Meggitt, 2006:2). Meggitt (2006:2) goes on to divide fine motor skills into gross manipulative skills and fine manipulative skills. The former refers to single limb movements such as throwing a ball by moving only one arm. The latter refers to the precise use of the hands and fingers, such as writing. Louw *et al*. (1998:238) note that motor development affects cognitive development, and can also enhance self-evaluation when children understand what their body is capable of doing. The development of complex motor skills depends upon the nervous system's growth, a process sometimes referred to as readiness, maturity or developmental level. This particular growth of the NS cannot be rushed. This means that the set sequence for developing motor skills cannot be easily altered. A child cannot walk if the changes in the NS necessary for walking have not yet occurred (Cheatum & Hammond, 2000:33).

Gabbard's (1992:12) phases of motor behaviour (refer to figure 3.8) indicate that the rudimentary movement phase corresponds with the stage of infancy where motor control is characterised by such behaviours as crawling, creeping, walking, and voluntary grasping. This voluntary motor behaviour occurs as the infant's NS matures, and these abilities appear in a very predictable sequence. Cheatum and Hammond (2000:37-38) refer to the stage between 18 to 24 months of life as the sensory-motor stage because

children learn mainly through movement and the sensory systems during this phase of development. They add that in order for the child's brain to develop, it must be stimulated or engaged in some activity within a rich environment that includes age appropriate experiences, movement activities, and interactions with others. De Jager (2010:2) stresses that, to make developmental progress, a baby should reach gross and fine motor skills in a set sequence. This sequence can be interrupted by abnormalities in the primary reflex system. There are close links between the inhibition of primary reflexes and the attainment of gross-motor milestones (Jordan-Black, 2005:101). This reflects the need to consider the child's reflex motor development if gross or fine motor irregularities are noticed. Each gross motor skill follows its own sequence. De Jager (2010:16) explains that crawling starts with head control, followed by trunk rotation and hip flexion. As sitting promotes propping the body up with both hands, it is also an important aspect in the run-up to crawling.

The sequence of a child's growth and development, as well as the order of motor control, generally develops in a ***cephalocaudal-proximodistal*** direction (Cheatum & Hammond, 2000:24; Gabbard, 1992:238). Cephalocaudal refers to the development from the head downwards and proximodistal refers to the development from the centre outwards (Cheatum & Hammond, 2000:24; Van der Westhuizen, 2007:115; Shaffer & Kipp, 2010:200-201). That is, functions appear and develop earliest in the infant's head and neck, then in the shoulders and upper trunk, and later in the lower trunk and legs. This is because the neurons between the brain and the muscles acquire myelin sheaths in a head-to-tail manner (Sigelman & Rider, 2009:136). The order also proceeds proximodistally from the shoulders to the elbows, and then to control of the fingers. Fine motor skills also develop more slowly than gross motor skills. Progression is therefore characterised by the performance of gross motor before fine motor acts (Gabbard, 1992:238; Meggitt, 2006:3; Keenan & Evans, 2009:105; Shaffer & Kipp, 2010:209). As the nerves and the muscles mature downward and outward, infants gradually gain control over the lower and peripheral parts of their bodies (Sigelman & Rider, 2009:136). Meggitt (2006:3) refers to these developmental concepts as the ***pattern of development*** and adds that apart from the cephalocaudal-proximodistal pattern, a

child's development also follows a pattern from

- simple to complex, for example, children stand before they can walk; and
- general to specific, for example, a young baby shows pleasure by a massive general response (smiling and moving all limbs vigorously), whereas an older child shows pleasure by smiling and with appropriate words and gestures.

Van der Westhuizen (2007:115) believes that this information about the pattern of development could be productively utilised in a therapeutic process that honours natural growth and development. This provides a rationale for considering the pattern of development when selecting and implementing the activities of the neurodevelopmental movement programme in this study; for instance, activities should start off begin simple and gradually progress to more complex movements.

Gabbard's (1992:12) fundamental movement phase (refer to figure 3.8) is a major milestone in early childhood (the preschool stage), and witnesses the appearance of body awareness, balance, running, jumping, twisting, bending, throwing, kicking and many more fundamental movements. Gabbard (1992:13, 258) states that these abilities establish the foundation for more complex human movement in later phases of development. In a South African study, Schröder (2004:135) explored the performance of a sample of children with hearing impairment, with a mean age of 60.6 months, in an urban special school in the Western Cape Province. The results of this study indicated that the majority (82.7%) of the sample appears to be well developed in terms of completing locomotor activities. Locomotor activities included walking up and down stairs, hopping, throwing and kicking a ball, and jumping over a rope, to name but a few (Schröder, 2004:78). 17.3% of the sample seemed to have limitations or difficulties in the area of motor skills. The low scores obtained by these children seemed related to comorbid conditions, such as cerebral palsy or autism, or other situations such as overprotective parenting. This study also found that 72.4% of the sample performed in the average to superior range with regards to eye-and-hand coordination skills. Eye-and-hand coordination skills referred to items relating to handwork and visual ability, such as threading beads, drawing, cutting of paper and writing (Schröder, 2004:79).

Schröder (2004:138) concluded that the sample appeared to be on chronologically track in terms of visual-motor ability. However, it is possible that this good performance might have reflected the fact that the majority of the children in that sample received intensive intervention from a multidisciplinary team, such as occupational therapists and physiotherapists.

In children, vestibular function plays a significant role in gross motor development (Kaga, Shinjo, Jin & Takegoshi, 2008). Wiley and Moeller (2007) state that 93% of children who are deaf or hard of hearing, without vestibular problems, develop gross motor skills at the same rate as hearing children. The only exception is when a specific aspect of the deafness affects balance or vision or muscle tone. A comprehensive discussion on the vestibular, vision, and muscle tone follows in chapter four where sensory-motor subsystems are discussed in detail. Suffice to mention here that these sensory-motor subsystems can influence gross motor and fine motor development. As mentioned, development within different domains or subsystems cannot be viewed as separate entities, but rather as interrelated to the development of the whole individual.

The next section elaborates on a child's personal and social development.

3.3.3 Personal-Social Development

Ding (2005:7) proposes that there have been some changes in the way psychologists view personal and social development of children. Children are no longer considered as passive individuals whose development is predetermined and influenced only by the interactions of others. Children are instead viewed as active participants in their own social development. They negotiate their own place in their social world and construct their own understandings of what is happening in their relationships with others. As early as the 1950s, Erik Erikson (Erikson, 1950:219, 222, 229), whose psychosocial perspective on child development has guided teachers, mental health professionals and parents for decades, stressed that children are active and curious explorers. Erikson stated that children seek to settle into their environments, rather than being passive reactors to biological urges who are moulded by their parents (Erikson, 1950:204;

Salkind, 2004:141; Shaffer & Kipp, 2010:44).

3.3.3.1 Erikson's Psychosocial Theory

Erikson's theory is described as the most influential theory of human development proposed thus far (Bee, 2000:35). A key concept in Erikson's theory is the steady surfacing of a sense of identity. To develop a stable identity, a person must move through and successfully resolve eight dilemmas over the course of a lifetime. Each stage (or dilemma) is defined by a pair of contrasting possibilities (Salkind, 2004:140; Shaffer & Kipp, 2010:44). One of these possibilities describes the most favourable outcome of that dilemma (refer to table 3.3). The other is the potential negative or less healthy outcome. The best resolution is, however, a balance between the two opposing possibilities (Gabbard, 1992:21).

Table 3.3 Erikson's Stages of Psychosocial Development

(Bee, 2000:36)

Approximate Age (Years)	Stage	Potential Strength to Be Gained
0 – 1	Basic trust vs. mistrust	Hope
2 – 3	Autonomy vs. shame and doubt	Will
4 – 5	Initiative vs. guilt	Purpose
6 – 12	Industry vs. inferiority	Competence
13 – 18	Identity vs. role confusion	Fidelity
19 – 25	Intimacy vs. isolation	Love
25 – 65	Generativity vs. self-absorption and stagnation	Care
65 +	Ego integrity vs. despair	Wisdom

Erikson's psychosocial theory concerned the development of personality, self-understanding, and a worldview that guides a person's orientation towards self and others over the life course (Newman & Newman, 2007:208). These crises are forced on every human as he or she moves through the life cycle. Each individual is pushed through these stages by biological maturation, social pressures, and by demands of life roles. The tasks that a person did not deal with fully may lead to unresolved issues.

This may interfere with a person's ability to find true integrity (Bee, 2000:35-36).

In the event that children in the study sample did not successfully meet the earlier challenges of basic trust vs. mistrust or autonomy vs. shame and doubt, it becomes more difficult to successfully meet the challenge of their current developmental stage, initiative vs. guilt. Beckett and Taylor (2010:35) explain that a child needs consistent and stable care in order to develop feelings of security, and subsequently the favourable outcome of trust in the environment and hope for the future, in the first stage. Also, the children in this sample must have been able to seek a sense of independence from their parents in order to develop a sense of autonomy and self-esteem to successfully conquer the second stage of Erikson's model. It is possible that, due to their living conditions as well as their sensory deficit, some of the children in the sample might have struggled to reach these favourable outcomes in either or both of these earlier stages. A large portion of the sample is growing up in unemployed single-parent households. With the exception of one child, the entire sample's primary caregivers are unfamiliar with sign language, and communication between the child with hearing impairment and their family is therefore negatively impacted.

The key dilemma to be mastered in the preschool years is *initiative versus guilt*. The child who developed a strong sense of autonomy in the previous stage, will now desire to explore the environment, to take action and plan new activities, to become more assertive, and to take more initiative. A child might even take on responsibility that is beyond his or her capacity to handle. When the environment allows and encourages such activities and avoids criticism or excessive restriction, a child's sense of initiative will grow. Where a child is too forceful or assertive, and the injury to others or objects leads to a sense of guilt. Although overwhelming guilt inhibits emotional growth, the successful resolution of this stage requires balance. The child must retain a sense of initiative, and yet learn to not intrude on the rights, privileges or goals of others. This stage is an important beginning step towards independence, and the family is the key social agent during this stage (Beckett & Taylor, 2010:35; Bee, 2000:36; Salkind, 2004:146; Shaffer & Kipp, 2010:45).

The school-aged child needs to deal with the demands of learning new and complex skills, or risk a sense of inferiority. Erikson refers to this stage as *industry versus inferiority*. This is a stage where children compare themselves with peers. Failure to acquire the social and academic skills to become sufficiently industrious may lead to feelings of inferiority. The child's ability to master certain skills becomes paramount. When children have no opportunities to learn to master their own world, or have their efforts to do so blocked, these unsuccessful experiences lead to their feeling inferior and unworthy. Teachers and peers are the significant social agents during this stage; for which the favourable outcome is a sense of competence and achievement, as well as confidence in one's own ability to make and do things (Beckett & Taylor, 2010:35; Bee, 2000:36; Salkind, 2004:147; Shaffer & Kipp, 2010:45).

In terms of Erikson's psychosocial theory, the children in this study sample are currently concerned with practising social assertiveness and initiative, and attempting to acquire the necessary social and academic skills to feel worthy, purposeful and competent. One cannot help but wonder how the challenges of being hearing impaired may influence their development of social identity. An overview on the impact of hearing impairment on the social and emotional development of the child was offered in chapter two. The remainder of this section expands briefly on the information presented in chapter two.

3.3.3.2 Social and Emotional Development and the Child with Hearing Impairment

Marschark (1993a:41) notes that that many of the earliest social interactions between mothers and their infants with hearing loss proceed normally and naturally, at least when the mothers are also deaf. None of these findings, however, speak to most infants with deafness, whose hearing parents have no idea of their deafness. These parents do not attempt to compensate for the lack of hearing with increased touching and other alternatives to replace maternal cues. Marschark (1993a:42) goes on to suggest that oral and manual communication (referring to sign language, facial expressions and touching) have functionally corresponding effects on early social-emotional development. This suggestion is confirmed when Manfredi (1993:61) considers that flexible communication modalities guarantee the construction of satisfactory

interpersonal relationships through which the child with hearing loss can develop self-confidence. Marschark (1993a:52) and Schröder (2004:51) postulate that when preschools offer more diverse social, linguistic, and cognitive experiences, this can only boost the flexibility of young children with hearing loss for dealing with later social interactions and the necessity of growing up in a largely hearing world.

Hindley (2003:77) concurs that parental responses and language delay are the major factors that can adversely affect deaf children's social and emotional development. Most children with a hearing disability do, however, develop a secure attachment relationship with their parents, except in cases where the parents do not accept their child's impairment. Children with hearing impairment's early emotional development do not appear to differ from their hearing peers, and in primary school they appear to have the same range of friends as hearing children. However, as they grow older, the population with hearing loss is more likely to have restricted emotional vocabularies, a restricted understanding of emotional processes and fewer friends in school (Hindley, 2003:78). This might be because they do not have the same opportunities as hearing children to interact and practice their social repertoire with adults and peers.

In the previously mentioned South African study, Schröder (2004:136) reported that 60.4% of the preschool hearing impaired sample's performance on the personal-social tasks indicated independence. Personal-social tasks assessed included activities such as personal cleanliness, efficiency at the table, the ability to wash hands and face, dress and undress, fasten buttons and the like. Some degree of social interaction was necessary from the child (Schröder, 2004:78). She related the results of the personal-social tasks to the specific preschool's emphasis on socialisation and experiential learning. She proposed that emotional problems such as parental overprotection, frustration and withdrawn behaviours impacted negatively on the portion of the sample who achieved within the below average to borderline categories. Schröder (2004:137) added that some children with hearing impairment might also have picked up clues to social behaviour visually; in so doing they may have misinterpreted what was being observed, and thus responded in a socially inappropriate manner, or not at all. She

goes on to explain that due to the children with hearing impairment's limited verbal abilities, their interaction with normal peers outside the school environment may limit their opportunities to practise social and personal skills.

This explanation seems highly likely. In the sample used in this study, it was evident from the researcher's school visits that the children struggled to communicate their needs and interests to those not proficient in sign language. Only one set of parents of the sample with hearing impairment had a hearing impairment, and were therefore proficient in sign language. The communication barriers that the vast majority of the sample's families may have experienced could have led to children not having had opportunities for a satisfactory interpersonal relationship with their parents. The children rarely see their parents during the school term and normally stay in the school's boarding facilities, as parents do not always have the sign language competence, nor the finances and time, to attend to the needs of their children with hearing impairment after school hours. Luckily the school boasts a caring and involved team of teachers, hostel parents and therapists that aim to foster good interpersonal relations between the children and the staff (Burmeister, 2010).

Cognitive, personal and social development are closely linked and mutually dependent (Ding, 2005:8). The next section focuses on cognitive development.

3.3.4 Cognitive Development

Cognitive development is defined as the changes that occur in children's mental abilities over the course of their lives. Mental abilities refer to activities such as attending, perceiving, learning, language, problem solving, thinking, and remembering (Sigelman & Rider, 2009:3; Shaffer & Kipp, 2010:249). Salkind (2004:230) and Shaffer and Kipp (2010:53, 249) are convinced that no theorist has contributed more to our understanding of a child's thinking than Jean Piaget (1896 – 1980).

3.3.4.1 Piaget's Cognitive Developmental Theory

In his cognitive-development theory (Piaget, Grize, Szeminska & Bang, 1977:7), Jean

Piaget focused on the growth of children's knowledge and reasoning skill as well as on changes in ***cognitive structure*** with age (Bee, 2000:145; Shaffer & Kipp, 2010:53). He used the word cognitive structure as a synonym for schemes (an organised pattern of thought or action that children construct to make sense of some aspect of their experience). He defined ***intelligence*** as a basic life process that helps an organism *adapt* to its environment and enhance one's chances of survival (Keenan & Evans, 2009:43; Shaffer & Kipp, 2010:250). Adaptation meant that the organism is able to cope with the demands of its immediate situation. At any age, children rely on their current cognitive structures to understand the world around them. They actively construct new understandings of the world based on their own experiences (Slentz & Krogh, 2001:23; Shaffer & Kipp, 2010:54).

Piaget also believed that every organism strives for equilibrium (Salkind, 2004:231). This includes a balance between cognitive, sensory and motor structures. When these structures are in balance, they provide an effective way of interacting with the environment. Any changes in the organism or the environment requires a revision of these structures, which leads to disequilibrium (Newman & Newman, 2007:82). In Piaget's theory, ***knowing*** is the process of achieving equilibrium. This process of knowing is a product of interaction between the person and the environment. When someone approaches a new situation, it is done with the expectations that developed in the past and in terms of the child's current cognitive structures. Each new experience will then change those expectations to some extent. The ability to understand an experience changes constantly, because individuals encounter the environment to be different each time. This then creates disequilibrium. The person then needs to put pressure on the mind to understand this new diverse experience to return to equilibrium. That means altering existing structures so that they provide a better explanation of the environment (Newman & Newman, 2007:83; Keenan & Evans, 2009:44; Shaffer & Kipp, 2010:54, 250). Piaget acknowledged that biological maturation of the brain and nervous system play an important role in this process. As the brain and NS mature, children become capable of increasingly complex cognitive structures (schemes) that help them to construct better understanding of what they experience (Shaffer & Kipp, 2010:55).

Piaget speculated that thoughts unfold in a series of biologically guided states that emerge in a fixed sequence as the person interacts with the environment. Shifts from one stage to the next occur gradually, rather than suddenly (Bee, 2000:145; Newman & Newman, 2007:84). He furthermore proposed four major stages (see table 3.4) of cognitive development, and suggested that all children progress through the stages in the same order (Bee, 2000:145; Salkind, 2004:242; Shaffer & Kipp, 2010:55, 253). An application of Piaget's theory of cognitive development to the study sample, shows that the children in the sample characteristically fit within the pre-operational stage of cognitive development.

Table 3.4 Piaget's Stages of Cognitive Development

(Gabbard, 1992:23; Bee, 2000:146; Shaffer & Kipp, 2010:55)

Piaget's Stages / Periods	Age	Major Developments
Sensorimotor (Infants only know objects by what they can do with them or how they experience them directly) o Simple reflexes o First habits & primary circular reactions o Secondary circular reactions o Coordination of secondary circular reactions o Tertiary circular reactions, novelty, & curiosity o Tertiary circular reactions o Internalisation of schemas	**Birth to 2 years** 1st month 1-4 months 4-8 months 8-12 months 12-18 months 18 months 18-24 months	• Infants learn that objects continue to exist when they are out of sight (object permanence). • Infants begin to externalise behavioural schemas to produce images or mental schemes.

Pre-operational thoughts o Symbolic function / preconceptual o Language development has strong impact on cognitive development o Progression from perception-bound to symbolic (images and language) thought o Inability to consider more than one aspect of a situation o Fantasy play and objects classification into groups o Egocentrism o Children are still tied to their own view o Intuitive thoughts o Primitive form of logic	**2 – 7 years** 2 - 4 years 4-ish 4-7 years	• Children become imaginative in their play activities. • They gradually begin to recognise that other people may not always perceive the world as they do.
Concrete operations o School-aged child: series of powerful mental actions that are components of logical thought (addition, subtraction, serial ordering etc.) o Inductive logic o Arriving at general principles by adding up specific experiences o Understands others' points of view o Cannot yet imagine things they have not known directly	7–11 years	• Children are no longer fooled by appearances. • They understand the properties of and relations among objects. • They are becoming more proficient at inferring motives by observing others.
Formal operations o Deductive logic o If-then reasoning o Approach problems systematically and examine all possible combinations o Can think about ideas and objects o More abstract and systematic thinking	11 / 12 yrs - into adulthood	• Adolescents enjoy pondering hypothetical issues (may become idealistic)

The pre-operational period is characterised by the appearance of the symbolic function. This refers to the skill of using symbols (such as images and words) to represent objects and experiences (Keenan & Evans, 2009:44). Language is possibly the most noticeable form of symbolism that young children display (Blum, Fields, Charfman & Silber, 1994:239). However, Piaget argued that language simply reflects what the child already

knows and believes that cognitive development promotes language development and not the other way around (Shaffer & Kipp, 2010:261). The pre-operational child also exhibits what Piaget referred to as egocentric speech. During this egocentric stage children do not differentiate between themselves and other people, and the verbalisations have no real communicative purpose (Salkind, 2004:253). Another major hallmark of the pre-operational period is the blossoming of pretend (or symbolic) play. These 'pretend' activities may contribute in a positive way to the child's social, emotional, and intellectual development (Shaffer & Kipp, 2010:261). Shaffer and Kipp (2010:271) mention that many researchers believe that Piaget underestimated the abilities of the preschool child and that they are not nearly as illogical or egocentric as Piaget assumed, a belief which led to several other theories of cognitive development. A brief delineation now follows.

3.3.4.2 Vygotsky's Sociocultural Theory and the Information Processing Perspective

The sociocultural theory of Lev Vygotsky (1896 – 1934) proposed that cognitive growth occurs in a sociocultural context (Vygotsky, 1978:3, 57) that influences the form it takes; and that many of a child's most notable cognitive skills advance from social interactions with parents, teachers, and other more competent associates (Keenan & Evans, 2009:44; Shaffer & Kipp, 2010:281). In other words, Vygotsky believed that children's intellectual development is closely tied to their culture, and that a child's mental abilities to solve problems and interpret their surroundings are consistent with the demands and values of their culture. Values and intellectual tools may vary substantially from culture to culture and the content of intellectual growth is not as universal as Piaget assumed (Shaffer & Kipp, 2010:281). Vygotsky also argued that thought and language ultimately joins together and illustrates the transition from prelinguistic to verbal reasoning. He concluded that non-social speech (private speech) is not egocentric, but helps young children to plan strategies and regulate their behaviour so that they are more likely to accomplish their goals. Language may thus play a critical role in cognitive development by making children more organised and competent problem solvers (Shaffer & Kipp, 2010:289). In this study, the sample's cognitive abilities and development can therefore not be separated from their language abilities, culture, rural environment and value

system.

By 1990, developmentalists had provided a framework for a new information-processing perspective on cognitive development. According to this theory, the human mind is like a computer into which information flows, is operated on, and is converted to answers, inferences, or solutions (Salkind, 2004:266; Shaffer & Kipp, 2010:57). This theory views cognitive development as the age-related changes that occur in the mind's hardware (the brain and the PNS) and software (mental processes such as attention, perception, memory, and problem-solving strategies). Unlike Piaget, who was vague about the connections between biological and cognitive development, the information-processing theorists contend that maturation of the brain and NS enables children to process information faster. The strategies that children develop for attending to and processing information are greatly influenced by their experiences, and are a continuous process that is not stagelike (Shaffer & Kipp, 2010:57). The speed of information processing is significantly influenced by increased neural myelination in the associative thinking areas of the brain and the elimination of unnecessary or excess neural synapses that could interfere with efficient information processing (Shaffer & Kipp, 2010:303). The researcher agrees with Shaffer and Kipp (2010:336) that the information-processing approach is a necessary complement to Piaget's earlier framework, in that it refers to the relationship between neural and cognitive development. The remainder of this section focuses on research findings pertaining to children with hearing loss and the cognitive challenges they might face.

3.3.4.3 Cognitive Development and the Child with Hearing Impairment

Research that has focused on specific aspects of the cognitive development of children with hearing impairment has yielded contradictory results (Marschark, 2003:466, 473). As mentioned in chapter one, the earliest investigations into the young child with hearing impairment's cognitive functioning concluded that these children were cognitively inferior and differed by several years in comparison to their hearing peers (Furth, 1964; Lister, Leach & Wesencraft, 1988; Pintner & Patterson, 1917). Studies of cognitive development using nonverbal measures suggest that children with deafness of hearing

parents show small but significant deficits in comparison with hearing children. Interestingly, the contrary is true for deaf children of deaf parents, who show small but significant advantages in comparison with hearing children (Hindley, 2003:78). A likely justification for this may be that deaf parents of deaf children use sign language from early on, and therefore experience the intimacy of a shared 'mother tongue' as well as all the social and cognitive benefits deriving from that (Blum *et al*., 1994:239). Children with deafness rely more on visual-perceptual thinking and visual memory and less on abstract thinking. It also seems that the child with hearing loss typically behave in concrete ways in various problem solving, academic and social situations. Hearing students were found to have greater coherence and consistency in conceptual organisation, whereas students with deafness had small and less defined sets of associations (Spencer, Deyo & Grindstaff, 1991:212; Marschark, 2003:465-471). The child with deafness shows an advantage over a hearing child in several domains of visuospatial processing (Marschark, 2003:473). Amid the findings of differences in between the deaf and the hearing, most results suggest that the two groups simply vary in their approaches to cognitive tasks (Marsharck, 2003:466).

In a study in which four children with deafness (aged 24 to 28 months) of four parents with deafness participated in play, it was found that there were no real differences between children with deafness and children with normal hearing (Spencer *et al*., 1991:217, 221). The children with deafness matched and sometimes even exceeded the hearing toddlers in the amount of time spend in play, as well as in the production of sequenced play and pre-planned play. In this study, natural supportive play with an involved adult (as opposed to play with peers) was monitored (Spencer *et al*., 1991:221). A study of the symbolic play in 16 children with deafness, aged one to three, was undertaken as a means to explore the formation of the symbolic capacities. The emergence of symbolic capacities is generally regarded as a key cognitive accomplishment, paving the way for a range of social and academic achievements (Blum *et al*., 1994:238). In children with a hearing disability who do not learn sign language, the appearance of the symbolic function as apparent in language is almost consistently strikingly delayed and altered. It is not yet known how the lack of audition or

the use of sign language may influence other aspects of symbolic development (Blum *et al*., 1994:239). Generally, however, the children with deafness in that study showed a capacity for symbolic play, although this developed at a slightly lower rate than in hearing children. The sample with deafness was capable of mental representation and could use toy replicas to represent real objects. Nevertheless, these capacities developed somewhat later and their uses were less consistent than in hearing children (Blum *et al*., 1994:254 - 255).

In a South African study in which the mental development of pre-schoolers with hearing impairment in a private school was assessed, Schröder (2004:139) reported that 70.7% of the preschool hearing impaired sample's achieved average to above average scores on the performance subscale of the Griffiths Scales of Mental Development. The performance subscale assessed skills in manipulation, speed and precision of activities requiring manual manipulation within time limits, as well as spatial perception. Test items included building stairs and bridges with blocks, the use of a form-board and pattern making (Schröder, 2004:79). Schröder (2004:139) noted that some of the performance of the sample might have been influenced by comorbid conditions such as eye problems, autism, cerebral palsy, slow cognitive functioning and ADHD. The performance of the same sample on practical reasoning tasks indicated that only 37.9% achieved at their chronological age level with regard to their higher order cognitive functioning (Schröder, 2004:140). Practical reasoning tasks included activities such as primitive arithmetical comprehension, and basic practical problem-solving. Attention and concentration span also plays a role on this subscale, and items included repetition of digits, as well as differentiation of objects in terms of size, weight, length and height (Schröder, 2004:80). Vocabulary and language skills are the basis for conceptual thought, which is necessary for achievement on this subscale. Schröder (2004:140) explained that due to the majority of the sample's underdevelopment in terms of vocabulary and language skills, most of the children performed lower than expected for their age in terms of conceptual thought. Overall slow development also contributed to low scores on the practical reasoning tasks.

Multiplicative reasoning is required in different contexts in mathematics. It is necessary to make sense of the concept of multipart units involved in learning value and measurement, and also to solve multiplication and division problems. These concepts are particularly important for mathematics achievement in school. A research study in the United Kingdom analysed whether 28 Grade One and Two children with hearing loss underperform in multiplicative reasoning problems for their level of nonverbal intelligence in comparison to hearing peers. The results of the study showed that children with hearing impairment underperformed at the beginning of their primary school years. However, it appears that this is a performance discrepancy rather than a competence discrepancy, as a brief intervention significantly improved their performance and brought them to the same level as that of the hearing sample in the study. The hearing children also profited from the intervention, and displayed more stable gains than those displayed by the children with a hearing disability. It is suggested that as hearing children are exposed to a richer problem-solving environment in the mathematics classroom than children with deafness, the former would continue to have opportunities to solve arithmetic problems and thus would continue to improve, whereas the opportunities for children with deafness to do so might be more restricted (Nunes, Bryant, Burman, Bell, Evans & Hallett, 2008).

It is therefore difficult to accurately evaluate the child with hearing impairment's cognitive development and skills, as this is greatly influenced not only by the tests used to assess this component of development, but also by the opportunities, stimulation and upbringing that children are given. Furthermore, it appears that the child with hearing impairment's cognitive problem solving ability may not necessarily be lacking, but rather could vary in terms of the approaches used to process such cognitive tasks.

Since language development forms an integral part of a child's cognitive development, and since this study focuses on the child with hearing loss, specific emphasis is placed on their development of language in the following section.

3.3.5 Language and Communication Development

Language is first and foremost symbolic (Lust, 2006:9). It is defined as a small number of independently meaningless symbols (sounds, letters, gestures) that can be combined according to agreed-on rules to generate an unlimited number of messages (Shaffer & Kipp, 2010:387). One of the truly astonishing accomplishments that sets humans apart from animals is their construction and use of language. More specifically, many have taken an interest in children's seemingly effortless acquisition of their first language (James, 2004:28); and as a result, several important and often diverse theories of language development developed. Rossi (2005:29) believes that these contrasting positions on the acquisition of language can influence one's view of normal versus delayed development in language. This section therefore commences with a brief overview on the most important language acquisition theories, and also discusses normal speech milestones to better understand normal language development.

According to the ***learning (behaviourist) perspective***, children learn language through imitation and reinforcement or repetition (James, 2004:28; Keenan & Evans, 2009:205; Sigelman & Rider, 2009:282; Shaffer & Kipp, 2010:390). In 1957, B.F. Skinner (Skinner, 1957:31, 57, 259) published a book entitled *Verbal behaviour* in which he argued that children learn to speak because adults selectively reinforce those aspects of babbling that most resemble words. This reinforcement increases the probability that these sounds will be repeated (James, 2004:29), and learning language is thus a matter of nurture (Sigelman & Rider, 2009:282).

As an alternative, the ***nativist perspective*** proposes that human beings are biologically programmed to acquire language by means of a language acquisition device (LAD). As such, speech is acquired in the same way as basic motor skills, by maturation (Rossi, 2005:29). The LAD refers to an inborn linguistic processor that is activated by verbal input. Linguist Noam Chomsky (Chomsky, 1959) argued that the LAD contains a universal grammar, or knowledge of rules that are common to all languages. The LAD thus allows for a child to acquire vocabulary, combine words into sentences and understand much of what is heard (Lust, 2006:54; Kalat, 2009:419; Sigelman & Rider,

2009:283; Shaffer & Kipp, 2010:391). In later literature (Slobin, 1985:1158) agrees with Chomsky, and adds that every child has an inborn language-making capacity (LMC), which refers to a set of cognitive and perceptual abilities that are highly specialised for language learning (Lust, 2006:66). From the nativist perspective, language acquisition is therefore very much natural and almost automatic, as long as children have linguistic input to process (James, 2004:33; Shaffer & Kipp, 2010:392). The knowledge of specialised structures (Broca's and Wernicke's areas) in the left hemisphere of the brain that help us produce and comprehend speech supports the nativist perspective (Pastorino & Doyle-Portillo, 2009:303). It is now widely recognised that we have an innate, biologically-based ability to learn language (Keenan & Evans, 2009:209).

The ***semantic perspective*** focuses on the link between cognitive development and language development (James, 2004:28). This approach sees the child as someone who actively tries not only to make sense of the world, but also to make sense of the language that forms an intrinsic part of it (James, 2004:33). As such, rather than believing that language development happens because the child has an innate LAD, this perspective argues that language development happens because the child has other cognitive skills. One of these skills is the highly developed capacity to make sense of human situations (James, 2004:34).

The debate continues about whether a child first acquires the concept of an object or an action before learning the appropriate word for that object or action (whether thought determines language) or the other way around (whether language determines thought). Discussions about whether language equals thought, or whether language and thought are independent is one of the oldest in philosophy (Marschark & Everhart, 1997:3). It does not fall within the scope of this section to explore the literature on this dispute, but it can be said that the consensus is that there exists a very strong link between thought and language. The nature of cognition in human evolution is such that it has a co-dependent relation with language that entails bidirectional influences (Everhart & Marschark, 1997:178; James, 2004:34). The semantic perspective and the interactionist perspective are often referred to as one (James, 2004:28). For the sake of clarity they

are discussed separately here.

Proponents of the ***interactionist perspective*** claim that biological factors and environmental influences interact to determine the course of language development; and that language is a result of a complex interplay between nature and nurture. Emphasis is also placed on the social and communicative nature of language (James, 2004:28, 35; Keenan & Evans, 2009:209; Shaffer & Kipp, 2010:395, 397). They therefore believe that both learning theorists and nativists are partially correct. They add that instead of a LAD or LMC, the powerful brain slowly matures, allowing children to gain more and more knowledge, which gives them more to talk about (Smith, 1994:43; Shaffer & Kipp, 2010:395). As illustrated in figure 3.14, the pattern of influence is reciprocal. The child's early attempts to communicate influence the speech of older companions, which in turn, provides information that the child can process to further develop the linguistic centres of the brain.

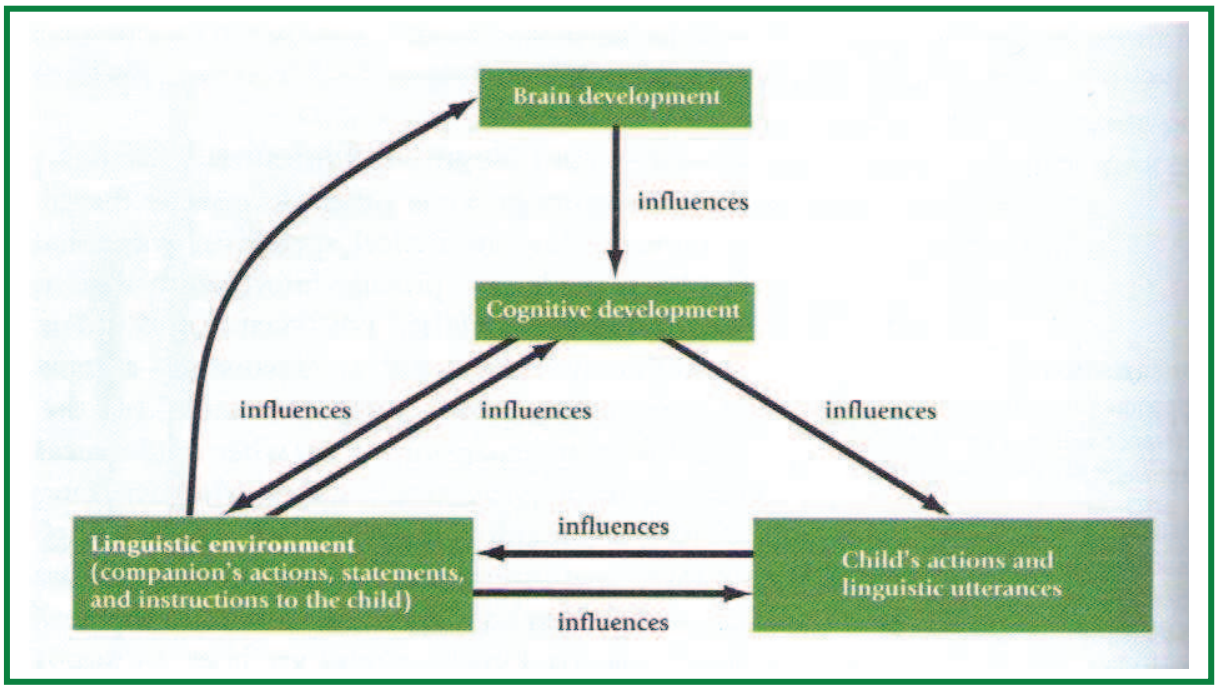

Figure 3.14 Interactionist Perspective on Language Development

(Shaffer & Kipp, 2010:398)

The researcher agrees with James (2004:28-29) that the above four perspectives or

language theories are not mutually exclusive. Each perspective contributes to the current body of knowledge on the language development in children. Irrespective of one's belief regarding language development, normal developmental milestones for language occur at about the same time for all children (Rossi, 2005:29). Children all over the world attain similar linguistic achievements at about the same age. The next section provides an overview on language development with a specific focus on the child with hearing impairment.

3.3.5.1 Language Development and the Child with Hearing Impairment

For the first 10 to 13 months of life, infants are said to be in the *prelinguistic phase* of language development. This refers to the period before they utter their first meaningful words (Sigelman & Rider, 2009:277; Shaffer & Kipp, 2010:399). The first vocal milestone other than crying occurs by two months of age; these prelinguistic vocal-like sounds ("ooohs" and "aaahs") are referred to as cooing noises. All babies babble by four to six months of age. This refers to the addition of consonant sounds to their vocal repertoires (Keenan & Evans, 2009:213; Pastorino & Doyle-Portillo, 2009:306; Sigelman & Rider, 2009:278). For the first six months of life, all infants across the world (even babies with hearing loss) sound pretty much the same. Babies with hearing loss will also cry and "coo" and they even begin to babble (Hoff, 2005:301). This is suggestive that early babbling is heavily influenced by maturation of the brain and the muscles controlling the verbal articulation of the sounds (Shaffer & Kipp, 2010:400). However, the effects of experience soon come into play and infants with hearing loss now begin to fall far behind hearing infants in their ability to produce well-formed, language-like phonemes. Babies with hearing loss will therefore not move beyond the initial babbling stage of speech as they cannot stimulate themselves through hearing (Rossi, 2005:29). Meggitt (2006:48) adds that babies with hearing loss stop babbling at around 12 months of age, because they also begin to learn the special manual gestures of sign language. Failure of otherwise healthy infants to produce syllables such as "da", "na", "bee", and "yaya" before 11 months of age should be considered a serious risk factor for hearing impairment (Eilers & Oller, 1994). Generally, infants seem to know much more about language than they can possibly say. This means that receptive language

(comprehension) develops ahead of productive (expressive) language from the 12th or 13th month of life and probably even sooner (Shaffer & Kipp, 2010:402). The *holophrase period* refers to the first stage of meaningful speech, where infants utter single words (Sigelman & Rider, 2009:279; Shaffer & Kipp, 2010:402). At about 18 to 24 months of age, children begin to combine words into simple sentences. These early sentences are referred to as the *telegraphic period* (Pastorino & Doyle-Portillo, 2009:307; Sigelman & Rider, 2009:280; Shaffer & Kipp, 2010:408).

Throughout the *preschool years*, children rapidly expand their vocabularies. In the short period between the ages of two-and-a-half and five years, children come to produce sentences that are astonishingly complex and adultlike (Sigelman & Rider, 2009:280). They acquire a number of conversational skills that help them to communicate more effectively and accomplish their objectives (Shaffer & Kipp, 2010:412, 415-416).

During *middle childhood*, children correct many of their previous syntactical errors (rules that specify how words are combined) and begin to use a number of complex grammatical forms that did not appear in their earlier speech. They improve their pronunciation skills, expand their vocabularies, and produce longer and more complex sentences (Sigelman & Rider, 2009:281; Shaffer & Kipp, 2010:417).

Children who are born deaf or who lose their hearing very early in childhood will have an extremely difficult time to learn an oral language, and spoken language is consequently often delayed (Hindley, 2003:77; Hoff, 2005:301; Pastorino & Doyle-Portillo, 2009:306; Shaffer & Kipp, 2010:410). Although some children with deafness do learn to lip-read and to speak, most achieve only limited success (Hoff, 2005:301). Children with hearing impairment who are exposed to sign language acquire it in much the same way that hearing children acquire an oral language (Hindley, 2003:77). Many children with hearing impairment produce their first sign at about the same time as or mostly slightly before hearing children utter their first meaningful word. Also, the language areas of the brain develop at much the same rate in children with hearing impairment exposed early to sign language as in hearing children exposed to speech. However, along with the

areas in the left hemisphere of the cerebral cortex that are involved in processing sentences, the child with a hearing disability's right hemisphere is involved because of the spatial skills involved in interpreting the gestures of someone who is signing (Shaffer & Kipp, 2010:410). Generally, a child with hearing impairment's expressive language ability can be more advanced than their receptive ability (Hindley, 2003:77; Wiley & Moeller, 2007). It appears therefore that learning sign language has many benefits for the child with hearing impairment for both communication and neurological development.

Unfortunately, because most children with a hearing disability have hearing parents, many are developmentally delayed when it comes to learning any form of language,. Findings indicate that the language development of deaf children of deaf parents is more similar to that of hearing children of hearing parents than to the development of children with deafness who have hearing parents (Marschark, 1993b:19). If parents do not already know and use sign language, they will fail to provide the much-needed stimulation for the infant with hearing loss to naturally acquire sign language in the same way that a hearing infant acquires a spoken language. Even when children with a hearing disability are later taught to sign they often do not catch up developmentally. It is only when children with deafness are exposed to sign language from infancy that they acquire sign language in a manner that is analogous to first language acquisition in hearing children (Pastorino & Doyle-Portillo, 2009:306). Burmeister (2010) reports that hearing parents rarely use effective means of communicating to their child with hearing impairment in their early years of life. In the study sample, all but one of the children were unacquainted with sign language before being enrolled in the school.

In the same South African study mentioned in preceding sections of this chapter, Schröder (2004:137) explored the performance of a hearing impaired sample of preschool children on the Hearing and Speech subscale of the Griffiths Scales of Mental Development. The minority of the sample (30.7%) fell within the average to very superior category, while 60.3% of the sample fell within the below average to cognitively impaired range. Hearing and speech activities included naming colours, naming similarities and opposites, repeating sentences with varying number of syllables,

identifying stimuli pictures cards and so on (Schröder, 2004:79). Schröder (2004:137) explained the low scores as being a direct result of the sample's sensory deficit and notes that it correlates with the Griffiths Scales case study profile of children with hearing impairment (Luiz, 1997:46). Learning to communicate therefore appears to be one of the greatest challenges that children with a hearing disability face.

Tibussek, Meister, Walger, Foerst and Von Wedel, (2002) explain that in order to develop verbal communication skills, an infant's nervous system needs sound stimulation, especially human speech, in the early and critical period of life. This acoustic stimulation is necessary during early infancy to warrant normal neural development. If auditory input is missing, brainstem auditory processing may be disturbed in relation to the severity of the hearing loss. Tibussek *et al*., (2002) further note that the influence appears to be greater if there was deprivation during an early critical period. Lim and Simser (2005) confirm that a lack of sensory stimulation to the brain prevents neural growth. The next subsection focuses on the concept of a critical period in acquiring language.

3.3.5.2 A Critical Period in Acquiring Language

The *sensitive period hypothesis* for general language development proposes that language is most easily acquired before puberty. Children deprived of a normal linguistic environment would therefore find it difficult to acquire language later in life. More than that, exposure to speech and language during the early years of life seems to have a lasting impact on a child's auditory, speech, language, and literacy development (Connor, Craig, Raudenbush, Heavner & Zwolan, 2006; Kalat, 2009:420; Shaffer & Kipp, 2010:393). A case study in the early 19th century addressed this idea when a 12 year-old feral boy named Victor was captured in the French countryside. Victor was declared mentally retarded and placed in the custody of Dr. Jean Marc Itard. Although Dr. Itard recorded some progress after daily intensive training sessions, Victor's failure to learn language supports a critical period of language development (Salkind, 2004:43). More recent findings imply that learning a language (or more than one language at the same time) is easier early in life. It is as if the cognitive system of the young child is especially

well suited for this task (Francis, 2005). Connor *et al*. (2006) suggest that both early and ongoing plasticity exists in the central auditory system and the systems of the brain that control speech and language development. A high degree of plasticity is particularly present before the age of two-and-a-half years in the neurological systems responsible for vocabulary development, predominantly associated with central auditory pathways.

Evidence from late American Sign Language (ASL) learning by children with deafness argues convincingly for an early critical period for language acquisition below age five. Adults with hearing loss who experienced little or no accessible language in early life performed poorly on grammatical judgement and sentence-to-picture matching activities. This suggests that language acquisition in early human development dramatically alters the capacity to learn any other language throughout life, independent of the sensory-motor form of the early experience. It thus appears that age constraints on language acquisition are not limited to spoken languages, but also apply to signed languages. Also, the age of acquisition is an important factor in the outcome of signed language acquisition (Mayberry & Lock, 2003). A child who learns a spoken language early, can learn sign language later, and a child with hearing loss who learns sign language early, can learn a spoken language later (albeit with poor pronunciation); however, someone who learns no language at a very young age is permanently impaired in learning language (Mayberry, Lock & Kazmi, 2002). Early first language acquisition can led to successful second language learning, even when the early first language is sign language and the later second language is reading a spoken language. This is a clear example of visual bilingualism. Strong first language skills in a visual language can support strong second language skills in a visual representation of a spoken language (Mayberry, 2007).

A child with hearing impairment's auditory language development only begins when amplification is first used. Lim and Simser (2005) explain that if a child is two years old when a hearing loss is identified and hearing is then amplified, that child is really only one day old relative to listening and language learning on the day the aid is fitted. When that child reaches a chronological age of three years, he is regarding as a one year-old relative to his listening experience. Linguistically, that child might sound more like a one

year-old than a three year-old. This expected gap between a child's chronological age and listening age can decrease over time, provided that the child uses appropriate amplification technology during all waking hours and enjoys active auditory-based intervention. The earlier a child is diagnosed and managed, the smaller the gap will be from the outset and the less the sensory deprivation (Lim & Simser, 2005). Connor *et al*., (2006) confirm this finding when they found that children exhibit early bursts of growth in consonant-production accuracy and vocabulary when they receive their cochlear implants before the age of two-and-a-half. In their study, magnitude of the early burst diminished systematically with increasing age at implantation and was not observed for children who were older than seven years at implantation.

A lack of sensory stimulation to the brain prevents neural growth and restrictive auditory brain growth. In the early 1980s researchers began to use auditory brainstem responses (ABR) to demonstrate changes and maturation of the central auditory pathway during infancy and childhood. Onset of synchronised auditory conduction in humans at around the 28th week of gestation is signalled by the simultaneous appearance of acousticomotor reflexes, and myelin in the auditory nerve, brainstem pathways and auditory cortex (Tibussek *et al*., 2002). In a retrospective study, 85 children with normal hearing and 165 children with binaural cochlear hearing impairment were examined in terms of the maturation of the auditory pathway (Tibussek *et al*., 2002). This was done by measuring ABR. The results indicated a marked delay in the maturation of auditory brainstem structures due to reduced auditory input during infancy. Therefore, fundamental deficits in central auditory processing may be assumed in affected children. This finding differed from results of comparable studies of adults, and leads to the assumption that the developing human brain is particularly sensitive to auditory deprivation. The exact age at which maturation of the ABR is completed remains uncertain, although there is general agreement that the most important changes take place during the first two years of life (Tibussek *et al*., 2002). It is therefore important to encourage a normal acoustic environment during sensitive periods in early childhood to ensure normal hearing and speech development, even in cases where children are born with a hearing impairment.

In light of this information, it is regrettable that most of the children in this study were diagnosed relatively late, did not have access to sign language before entering school, and still do not have access to hearing aids at all times. This is likely to have a negative and lasting impact on their auditory, speech and language development.

3.4 CONCLUSION

This chapter began with an overview on developmental constructs with the emphasis on development as a holistic process, with changes in one domain or aspect of a child's development influencing other developmental aspects of a child's overall development. Discussions on child development followed in terms of different developmental domains. Consideration was given to neurodevelopment and the organisation of the nervous system, followed by a discussion on locomotor, personal-social, and cognitive systems, and lastly, a consideration of language development and communication. Relevant developmental theories were integrated to aid an understanding of normal child development. The discussion of neurodevelopment in terms of time and maturation was considered an important addition as knowledge of these concepts and the developmental hierarchy that they follow offer insight into a child's development, and aid the identification of possible neurodevelopmental delays.

During the literature review it became clear that the child with hearing impairment's overall development and skills is greatly influenced not only by the tests used to assess these components of development, but also by the opportunities, stimulation and upbringing that a child has had. However, it appears that children with hearing loss are more likely to experience the following:

- They may score lower on the ***Hearing and Speech (Language)***, and language-reliant ***Practical Reasoning*** subscales of the GMDS-ER (Schröder, 2004:137; 140).
- If the cause of the deafness influences the balance, vision or muscle tone of a child, one can also expect the ***Locomotor Subscale*** of the GMDS-ER to be negatively influenced due to gross motor and coordination difficulties. However, children with hearing impairment with no vestibular problems do not usually experience gross motor delay (Wiley & Moeller, 2007).

- Children with hearing impairment are inclined to have ***aberrant ATNR and STNR reflexes*** (Rosen & Joffee, 1995:501), possibly also as a result of irregular vestibular functioning, as dysfunctions in this system may alter the level of reflex response (Goddard, 2005:58).
- Apart from gross and fine muscle coordination, and depending on the degree of aberrant reflex activity, this poor nerve fibre organisation may affect other areas of functioning, such as sensory perception and cognition (Van der Westhuizen, 2007:100).

Chapter four focuses on the sensory-motor systems, and introduces the neurodevelopmental movement programme as an intervention for neurodevelopmental delay.

CHAPTER FOUR

THE NEURODEVELOPMENTAL BASIS OF HUMAN MOVEMENT AND MOVEMENT INTERVENTIONS

"The brain is without doubt our most fascinating organ. Parents, educators and society as a whole have tremendous power to shape the wrinkly universe inside each child's head, and, with it, the kind of person he or she will turn out to be. We owe it to our children to help them grow the best brains possible."

(Eliot, 2000:10)

"Movement awakens and activates many of our mental capacities. Movement integrates and anchors new information and experiences into our neural networks. And movement is vital to all the actions by which we embody and express our learning, our understanding and ourselves."

(Hannaford, 2005:107)

4.1 INTRODUCTION AND CHAPTER PREVIEW

In the previous chapter's discussion on the developmental sequence of the embryo and the brain, it was noted that the brain develops and matures from the spinal cord to the higher cortical areas. The establishment of brain hierarchy starts at the brainstem level and slowly moves forward towards the frontal regions of the brain (Goddard, 2005:42-46). This chapter elaborates on perceptual and sensory-motor systems, which also follow a developmental hierarchy; as well as their impact on a child's development and ultimate readiness to learn. In order to understand the neurodevelopmental basis of human movement, an explanation of the systems that control movement is required. A more comprehensive discussion on neurodevelopmental delay continues in this chapter, which concludes with a general conceptualisation of movement, the significance of movement in early childhood development, and the effect of movement interventions on learning.

4.2 PERCEPTUAL AND SENSORY-MOTOR CONCEPTS

A relationship has been identified between gross motor ability in preschool children and cognitive performance once they reach school age (Piek, Dawson, Smith & Gasson, 2008:668-680). These researchers recognise the essential role of early motor experiences and development as a basis for perceptual and, later, cognitive functioning. Chapter three presented an essential framework for this understanding. This chapter elaborates on this and presents more detail on sensory-motor systems.

As described in the preceding chapter, in the reflexive and spontaneous movement phase, the young baby has no cortical influence over movement and planned action. As the toddler inhibits primitive reflexes and thus gains more cortical control, additional brain structures develop and the functioning of various areas in the brain increases. This progression is seen in infants' gradual ability to differentiate between and move parts of their body independently. This ability to *differentiate* between different body parts eventually leads to lateralisation. *Lateralisation* refers to the awareness of the two sides of the body. Being able to control and coordinate the two sides of the body together involves being able to cross the body's midline. Once midline crossing becomes automatic, the brain is able to share information over the 'neurological midline', namely, the corpus collossum. This allows for *interhemispheric integration* (Van der Westhuizen, 2007:116-117). A brief overview of each of these components follows.

4.2.1 Differentiation

The term ***differentiation*** was used during the discussion on neurodevelopment in the preceding chapter where it referred to the changing of neurons into their different types. Zillmer, Spiers and Culbertson (2008:116) define differentiation as the process of increasing regional specialisation of cells. This process of differentiation refers to a phase of prenatal CNS development that originates when migrating neural cells reach their predetermined destinations within the brain. As the neural cells reach their destinations, they develop the unique characteristics of the cells specific to that brain region (Zillmer, Spiers & Culbertson, 2008:517). The high sensitivity of the developing dendrites to the effects of environmental stimulation fosters the growth and

differentiation of the brain (Zillmer, Spiers & Culbertson, 2008:117).

In earlier literature, another definition of ***differentiation*** in child developmental terms referred to the sorting out or the separation of body parts from each other in a cephalocaudal and proximodistal direction (Heiniger & Randolph, 1981:162; Randolph & Heiniger, 1994:104). The reader will remember from the discussion in the former chapter that cephalocaudal refers to development from the head downwards, and proximodistal refers to development from the centre outwards. That is why a baby's neck needs to strengthen to carry its head long before the baby can walk, and why hands always tend to be more sensitive and skilled than feet. It also explains why a baby first has more control over the trunk of the body before control over the fingers (De Jager, 2011:17-18).

In a more comprehensive discussion, Randolph and Heiniger (1994:171-172) write that body awareness involves three elements: body schema, body image and body concept. ***Body schema*** begins to develop with prenatal movement patterns. As the child grows, sensation, motor generalisations and perceptual-motor matching help to provide increasing control of the body. By moving, children develop the body schema that includes an innate understanding of their centre of gravity, the position of their body in space, how much space their body takes up and how much space is needed for their body parts. Cheatum and Hammond (2000:98) and De Jager (2011:14) refer to this as a process of developing a map of one's own body and later, developing a map of the world around one. This map starts to develop in a foetal brain around the 9th or 12th week of pregnancy and depends upon sensation received through activities involving the muscles, joints, skin, and soft tissue (Cheatum & Hammond, 2000:96). Maps are created every time that each of the senses sends information to specific parts of the brain to create rich and multisensory maps of the body and the world (Cheatum & Hammond, 2000:97; De Jager, 2011:15). This leads to the ability to identify and name the parts of the body. This knowledge of body parts usually follows the developmental trend of cephalocaudal to proximodistal (Cheatum & Hammond, 2000:85). Cheatum and Hammond (2000:92) found that children with average and above average learning

ability were more successful in identifying body parts than were those considered to have learning disabilities or learning problems.

Body image is how the body appears to us, while ***body concept*** is defined by our evaluation of our body. Randolph and Heiniger (1994:172) explain *body concept* as being more cognitive than body image and body schema: it is our thought process for understanding, planning, and evaluating the functions of our bodies. In brief, it is our conscious understanding of who we are and how our bodies work. Cheatum and Hammond (2000:85) differ from other theorists in that they use the term *body image* to refer to a child's self-image and the feelings a child has about himself or herself. Regardless of semantic differences, it is clear that children's evaluation of their body, whether termed *image* or *concept*, is positively enhanced by the successful experience of moving and controlling their bodies in the environment.

Children with schema problems have trouble with coordination. Again, it was found that students experiencing learning difficulties also had body schema problems (Cheatum & Hammond, 2000:98). De Jager (2011:15) clarifies that inaccurate maps and difficulty in using these maps can lead to babies experiencing developmental delays and children having learning difficulties later in life.

These views not only emphasise the significance of body awareness but also link closely with Zillmer, Spiers and Culbertson's (2008:117) assertion that brain differentiation and growth depends on environmental stimulation. Differentiation is the precursor to the development of lateralisation.

4.2.2 Lateralisation, Midline and Directionality

The term hemispheric asymmetry refers to the differentiation in morphology, function and physiology between the two hemispheres of the brain (Kolb & Whishaw, 2009:276; Zillmer, Spiers & Culbertson, 2008:162). The terms ***lateralisation*** and dominance refer to the differences in functional specialisation between the two hemispheres (Ayres, 2005:34; Zillmer, Spiers & Culbertson, 2008:162).

The development of ***laterality*** depends on the information gained through the body concept and body schema stages of development (i.e., during the differentiation stages of development). Laterality is the internal awareness that there are two sides of the body and that these sides are different. Laterality starts to appear around the fourth year and is very important for school, as this awareness plays a significant role in a child's academic success. Until laterality develops, a child will have trouble with the concepts of reading and writing from left to right. By the age of eight or nine, most children should be able to correctly identify the left and right parts of their bodies (Cheatum & Hammond, 2000:101).

Lateral preference (or hand/eye dominance) refers to favouring the use of one eye, hand, or foot over the other. It is an anticipated result of a child's advancing through a normal developmental sequence, and it should occur naturally. Lateral preference is the ability to use one side of the body more competently than the other, and it plays a vital role in future academic learning and success in motor skills. By the seventh or eighth month a baby should begin to favour one hand, which is more often the right-sided one. This preference may shift back and forth, greatly depending on whether the desired object or person is near the baby's left or right hand. Lateral preference is usually established by the age of three or four. The awareness of dominance that develops in the preferred side of the body is the foundation that children need in order to determine which objects are above, below, to the right, or to the left of their bodies or other objects. Various subjects such as reading, writing, and physical education can become problematic if lateral preference has not developed. Pure lateral preference refers to the preference for using the eye, hand, and foot on the same side of the body. Mixed preference (cross dominance) exists when a child does not favour the eye, hand, and foot on the same side of the body. In other words, there may be a preference for the right eye, left hand, and right foot. About 20% of the population has mixed preference, and if the child is succeeding in school and movement activities, there should be no cause for concern (Cheatum & Hammond, 2000:105-106; Kokot, 2007a:40-41). When developmentally delayed individuals are slow to establish hand preference, this may be because they are still under the control of the more primitive mechanisms of the brain's

immature organisation (Kinsbourne, 2009:54).

Laterality serves as the foundation for ***directionality***. During this developmental step, a child transfers knowledge of the right and left sides of the body into space. It involves three references: right and left, up and down, as well as before and behind. Children first learn the three directional references in relation to their own body, and then project this knowledge into space and onto other objects (Cheatum & Hammond, 2000:115; Kokot, 2007a:43). References to directions are constantly used in teaching and it is therefore essential that children have mastered directionality in order to complete classroom tasks successfully. A child who is still in the laterality stage and does not know right and left, lacks directionality, or does not have a sense of up and down, will continue to confuse letters such as *p*, *q*, *b*, and *d* (Cheatum & Hammond, 2000:116-117). Deficits in this area show up in reading when a child is expected to see words consisting of letter combinations, read from left to right, and hold a book right side up to read (Krog, 2010:66).

The ***midline*** refers to an imaginary line that divides the body into a right and left side. It pertains to laterality in that crossing the midline usually occurs automatically after a child has developed laterality (Cheatum & Hammond, 2000:113). In the early stages of development, the midline is like a wall that keeps a child from crossing one arm or leg across the centre of the body into the other half (Cheatum & Hammond, 2000:110). An infant's tendency not to reach out and cross the midline seems to be a consequence of immature brain organisation (Kinsbourne, 2009:54). Between eight to twelve months, most babies gain the ability to reach across the midline of their bodies to pick up an object. It is of concern when a child reaches the age of five and cannot cross the midline. Crossing the midline can be sometimes delayed until a child is seven years old, because crossing only occurs automatically after a child has developed lateral preference (Cheatum & Hammond, 2000:110; Kokot, 2007a:41). Inability to cross the midline also affects the visual system, as the child will then use the right eye to read or write on the right side of the page of the midline and the left eye on the left side of the page. This switching of the eyes leads to confusion, and children frequently lose their

place or skip lines (Cheatum & Hammond, 2000:111). Children with midline problems also have trouble in both academics and physical education (Cheatum & Hammond, 2000:113), and it may have a devastating effect on school performance (Krog, 2010:66). The ability to cross one's midline is not only a necessary component for mature lateralisation, but also ultimately for interhemispheric integration (Van der Westhuizen, 2007:119).

4.2.3 Interhemispheric Integration

As discussed in chapter three, the human brain is composed of two hemispheres. The left hemisphere receives motor and sensory input from the right side of the body and the right hemisphere receives input from the left side of the body (Kokot, 2007a:48; Krog, 2010:66). Each hemisphere also has a distinct manner in processing information. The left hemisphere is more adept at attending to and processing more fine-grained information and the right hemisphere more adept at attending to and processing more coarse-grained information. This distinction holds for both verbal and spatial bits of information (Banich, 2010:228). ***Interhemispheric integration*** refers to the communication between the left and the right cerebral hemispheres of the brain. To function efficiently, we need to integrate information from various specialised centres to coordinate a planned response (Kokot, 2007a:48). Interhemispheric integration occurs mainly via the enormously rich bundle of nerve fibres connecting the cerebral hemispheres, the corpus callosum (Banich, 2010:228). Bilateral integration means that the two sides of the body can work together, and implies the coordination of the left with the right side. It also makes it possible to use each side of the body separately in order to successfully complete a task (Goddard, 2009:5; Kokot, 2007a:41).

Sucking and crawling are two activities of infancy that help to develop interhemispheric integration (Kokot, 2007a:49), but ultimately integration of the two hemispheres relies on optimal development of differentiation and lateralisation (Kokot, 2007a:49; Van der Westhuizen, 2007:119). As most mental processes involve both sides of the brain, integration problems between the two hemispheres can result in inefficiencies in brain processes resulting in reading problems, central auditory processing difficulties,

language deficits and other learning problems (Kokot, 2007a:48).

4.2.4 The Sensory-Motor System

The brain makes sense of information received via the NS from the sensory systems (such as touch, sound, sight, and the like). Once this has happened, the brain is capable of directing the body to respond to the stimuli. This reaction usually occurs in the form of one or another movement, hence the term ***sensory-motor system*** (Kokot, 2010a:13). The most familiar senses of hearing, seeing, taste, smell and touch are sometimes referred to as the "far senses" or the "outside senses" because they respond to external stimuli that come from outside the body. These senses are also referred to as exteroceptive systems. The "near senses" or the "inside senses" on the other hand receive stimuli from somewhere inside the body (such as the vestibular and proprioceptive systems); and a person is generally unaware of them and cannot control them. These interoceptive systems monitor internal bodily events and inform the brain of the positions of body segments relative to one another and of the position of the body in space (Cheatum & Hammond, 2000:128; De Jager, 2011:11, 14; Goddard, 2011:11; Kokot, 2007a:51; Kolb & Whishaw, 2009:213).

The senses in the sensory-motor system are the underlying subsystems that form the neurological system (Van der Westhuizen, 2007:137). The healthy development of the sensory systems is vital to ***learning readiness*** (Kokot, 2007a:51; Krog, 2010:68). Learning readiness means that child's brain is *wired to learn*. In essence this refers to a well-developed neural network that comprises the NS and enables the brain to take in information from the outside world, process the information, and respond to it through appropriate movements (Kokot, 2010a:21-22). Movement is an essential part of learning and thinking (Hannaford, 2005:120). The concept of *learning readiness* includes the idea of ***school readiness***, but does not refer to the same construct. Kokot (2010a:23-24) explains that a child may pass a school readiness test, indicating that the child has developed certain abilities needed to perform in a classroom setting. These include the ability to sit still and listen, manipulate a pencil, get along with peers and show certain perceptual and cognitive skills. However, many of these tests do not

investigate the child's level of neurodevelopment (or their *readiness to learn*), which refers to the foundation of neurological systems on which school readiness abilities rests.

Adding to the discussion on ***neurodevelopmental delay*** in the previous chapter, it is important to note that although reflexes provide the foundation for later learning, by the time the child reaches the age of eight years, other systems will also have become involved. The reflexes are therefore only one sign of misdirection in development, which may then be accompanied by dysfunctions in the processing of auditory information, visual information, vestibular functioning and the like (Goddard, 1996:86; Goddard, 2005:130). Goddard (1996:108) explains that the process of reflex inhibition and transformation aids in opening up neural pathways. Hannaford (2005:35) adds that nerve networks grow out of unique sensory experiences, laying down complex patterns that govern all higher level brain development. Motor behaviour should be the product of a system in which brain and body work together to form an interactive system of response, action and expression. Messages should thus be communicated with equal efficiency from brain to body and back again. If this is disrupted in any way, then subsequent motor and sensory functions may be affected, changing the transmission of messages from one system in the body to another. The result is that the altered transmission of messages from one system in the body to another distorts perceptions, and their transposition from sensory experience into thought, language, emotion, and even the ability to deal with that sensory experience itself (Goddard, 2005:150). In order to be able to learn easily and cope with the demands of the classroom and life in general, children therefore need to have reached a level of brain and body development that will support their functioning. Whether they do so or not depend on how well they develop certain systems within their bodies that are needed to support their learning (Kokot, 2010a:24). Any difficulties with receiving, organising, interpreting, or responding appropriately to the vast amount of information that enters the sensory systems can create problems (Cheatum & Hammond, 2000:135).

An overview on the sensory systems and the developmental hierarchy of these systems

forms the focus of the following subsection. The olfactory (the sense of smell) and the gustatory (the sense of taste) systems are excluded from this discussion, with the emphasis rather on four of the five most vital sensory systems for developing learning readiness through movement. They are the vestibular, proprioceptive, tactile, and visual senses (Cheatum & Hammond, 2000:127; Kokot, 2007a:53). A comprehensive delineation of the fifth important sense, the auditory system, was presented in chapter two. Although the subsystems are discussed individually and in isolation, these senses do not develop or operate in isolation and each one is reinforced, modified and influenced by information from the others (Goddard, 1996:42; Goddard, 2005:56).

Sensory integration is a phrase use to describe the ability of the brain to receive, organise, interpret, and use the enormous amount of sensory information that enters the body and neurological system through both external and internal stimuli. All these stimuli must be integrated and interpreted before children can successfully function in the world around them (Ayres, 2005:36; Cheatum & Hammond, 2000:132). Goddard (2005:56) states that it is crucial to understand the senses and how they complement one another. Such knowledge is needed to understand and help children who cannot make sense of the world and so have difficulty learning through accepted channels of education. This is even more relevant in the case of children who lost the function of one or more of their senses.

4.2.4.1 The Vestibular System: Motion and Balance

The ***vestibular system*** is the first of the sensory systems to develop, being formed at just eight weeks after conception, functioning at 16 weeks after conception and myelinated at the time of birth in a baby born at full term. It is possibly the oldest and the most primitive of the sensory systems. This system not only controls the sense of movement and balance (Goddard, 2005:57; Goddard, 2011:14; Hannaford, 2005:38), but is also the sensory system considered to have the most important influence on the other sensory systems (Cheatum & Hammond, 2000:143). Cheatum and Hammond (2000:143) refer to the vestibular system as the *unifying system* in the brain that modifies and coordinates information received from other systems, such as the visual,

proprioceptive, auditory and tactile systems. The eighth cranial nerve (auditory-vestibular cranial nerve) is also the first cranial nerve to develop, at five to six months in utero. This nerve stems directly from the vestibular system (Hannaford, 2005:38).

The reader was first introduced to the vestibular system in the discussion on the anatomy of ***the inner ear*** in chapter two. The inner ear is concerned with both hearing (auditory system) and balance (vestibular system) (Cheatum & Hammond, 2000:144).

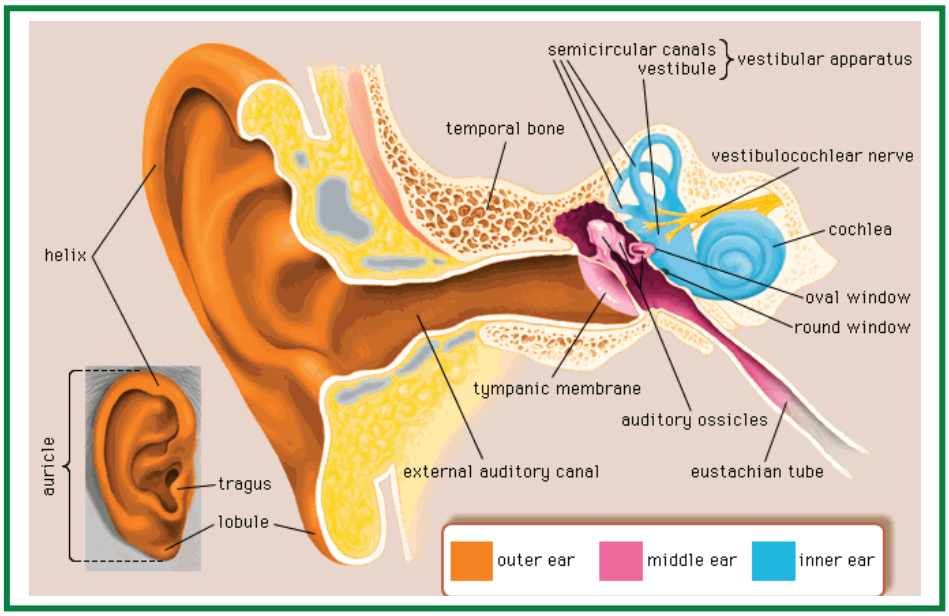

Figure 4.1 Structure of the Human Ear

(Encyclopaedia Britannica, 2011b)

The illustration in figure 4.1 reiterates the structures inside the inner ear, collectively referred to as the vestibular system. Chapter two stated that the inner ear contains the organs that allow us to perceive our own motion and assist us in standing upright without losing our balance. The structures making up the vestibular system are the three fluid-filled semicircular canals and two fluid-filled vestibular sacs – the vestibule (Goddard, 2005:57; Kokot, 2007a:54; Nandi & Luxon, 2008).

Figure 4.2 offers a more detailed illustration of these structures. The three semicircular canals are orientated in three planes that correspond to the three dimensions in which

we move, and so respond to any movement of the head. These canals rest at approximately a 90 degree angle to each other and maintain dynamic equilibrium by detecting imbalance in three planes. The canals are shaped like tunnels, with one end of each canal opening into the utricle and the other end opening into an enlarged area called the ampulla. The otolith organs or the vestibule (referring to the utricle and the saccule) detect linear acceleration of the head and are also responsive to changes in the position of the head with respect to gravity. In addition, these organs are sensitive to the static position of the head in space, in contrast with the semicircular canals' sensitivity to head movement (Bundy, Lane & Murray, 2002:53; Cheatum & Hammond, 2000:143-144; Goddard Blythe, 2004:17-18; Goddard, 2005:57-58; Hannaford, 2005:40; Kolb & Whishaw, 2009:216; Nandi & Luxon, 2008).

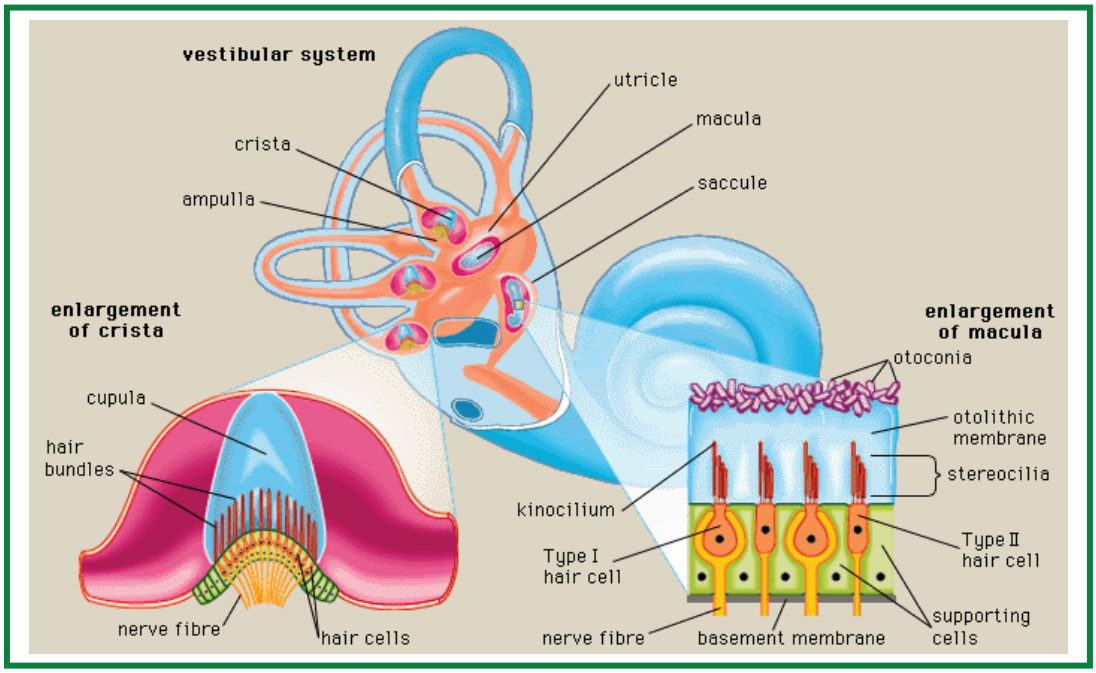

Figure 4.2 Vestibular System

(Encyclopaedia Britannica, 2011a)

At the connection between the ampulla and the semicircular canals is a gelatine-like mass that contains hair cells. Both the utricle and the saccule also have a group of hair cells that lie in gelatinous masses. Hair cells thus line the inside of both organs. These hair cells bend when the body moves forward or when the head changes position relative to the body. This is possible as endolymph fluid in the semicircular ducts flows over the hair cells. The bending of the hair cells initiates sensory nerve impulses along

the eight cranial nerve to a number of vestibular nuclei in the brainstem. These nuclei interact in the hindbrain (more specifically the cerebellum) to help keep us balanced while we move. The vestibular system is the only sensory system with direct connections to the cerebellum (Bundy, Land & Murray, 2002:57). Projections come from the vestibular nerve directly and from vestibular nuclei. In turn, there are direct connections from the cerebellum to the vestibular nuclei. These interconnections are important for ongoing control of eye and head movements as well as posture. Ultimately, information from the vestibular system allows us to record and replay the movements that we have made through the connections in the cerebellum. Goddard (2009:247) explains that the vestibular system works together with the cerebellum to achieve good balance, adaptability and flexibility in movement. The nuclei also aids in controlling eye movements at the midbrain level. Each eye is controlled by six pairs of muscles that receive stimulation from the vestibular system. The vestibular system, the reflex system and the visual system are all closely aligned, acting as the foundation upon which oculo-motor (eye movement) and visual-perceptual skills are built. Higher cognitive skills such as reading and writing also require directional awareness, which depends upon stable balance. The vestibular system also influences the prearousal part of the brain and so controls alertness and the ability to focus. The vestibular system furthermore has a strong influence on the muscles that control posture. It is hypothesised that vestibular and proprioceptive processing jointly contribute to the perception of active movement, the development of a body schema and the development and use of postural responses, especially those involving extensor muscles (Bundy, Lane & Murray, 2002:58). The vestibular system connects directly or indirectly to every muscle in the body, and causes the motor system to increase or decrease its impulses to specific muscles to contract or relax. As a result, the vestibular system has a strong influence on postural muscles, postural control and stability (Ayres, 2005:36; Bundy, Lane & Murray, 2002:57). This includes ***muscle tone*** and the strength needed to sit in a chair, hold the neck steady for academics, or compete in sport. The connection between the vestibular system and cortex as well as the eyes and core muscles is highly important to the learning process (Ayres, 2005:41, 61; Cheatum & Hammond, 2000:144-155; Goddard Blythe, 2004:17-18; Goddard, 2005:57-58;

Hannaford, 2005:40; Kolb & Whishaw, 2009:216).

Muscle tone is the degree of tension normally present when our muscles are in a resting state (muscles never relax completely unless one is unconscious) (Kranowitz, 2005:124). The lack of muscle tone that accompanies a hypovestibular condition often creates academic and social problems for children and frequently leads to a damaged self-esteem or body image in a child. This happens because children with low muscle tone tend to not know where they are in relationship to space and other people and may stand either too close to other students or run into them. They are often clumsy and therefore may not excel in sport activities. They find it particularly difficult to control themselves against the downward pull of gravity. Most of the time, their problems revolve around the vestibular system (Cheatum & Hammond, 2000:163-164). ***Tonic or static muscle control*** refers to a child's ability to contract a muscle or a group of muscles and hold them in that position for several seconds. Such control is essential for a variety of positions in the classroom and in physical education (Cheatum & Hammond, 2000:150). If a child does not have enough tonic muscle control to hold a body part steady, they will rely on phasic muscle control. This refers to the repeated contraction and relaxation of a group of muscles, and ultimately leads to an inability to sit still (Cheatum & Hammond, 2000:164). It is likely that difficulties in the vestibular system have ramifications for all other areas of functioning.

Early maturation of the balance system suggests the crucial role that balance plays in enabling a child to function well in a gravity-based environment. Without balance it would not be possible to sit, crawl or stand. It would be impossible to control the movements of one's eyes or integrate information derived from the other senses to form a coherent perception of the outside world. If information from the vestibular system is out of alignment with information from the other senses, motion sickness results (Goddard, 2005:57; Goddard, 2011:14). Hannaford (2005:38) considers the vestibular system to be the entryway into the brain as this unifying system is either directly or indirectly involved in nearly everything one does. Problems in the vestibular system will affect the other sensory systems, because all sensation passes through the vestibular

mechanism at brainstem level before being transmitted elsewhere for analysis (Goddard, 2005:56). Goldberg, Wilson, Cullen, Angelaki, Broussard, Buttner-Ennever, Fukushima and Minor (2012:4) elaborate that the fibres of all five sense organs (referring to smell, taste, auditory, vision and touch) travel to the brainstem and terminate in the vestibular nuclei. The vestibular system is indeed the interface between sensory and motor systems.

Although the balance system is formed and ready for use at birth, it will take a young child many years to learn how to use the system efficiently (Goddard, 2011:14). Such learning starts with movement. Goddard (2004:16) said that although the vestibular system may be the expert *in* movement, it receives its training *through* movement. When children do not move and activate the vestibular system, they are not taking in information from the environment. Every movement stimulates the system, which in turn stimulates the brain for new learning. Beginning with only reflexive movements at birth, through learning to sit, walk and run, and then to hop, spin and balance on a beam, a child's body will have developed readiness to learn by the time they enter formal schooling. Secure balance is impossible without the development of postural control, which in turn is supported by information from the visual, proprioceptive, and motor systems. Training of these systems is a gradual process, during which maturation of the vestibular pathways involved takes until at least seven years of age, and continues through puberty and beyond (Goddard, 2004:17; Hannaford, 2005:42). De Jager (2011:75) believes that every single movement of a pregnant mother registers with the baby's vestibular system and is serves as a brain developmental boost for the baby. She adds that once that baby is born, it needs to move around unhampered in order to fight the pull of gravity and learn to control its head, as head movement leads all physical development. Maturing vestibular function in children can be associated firstly with general motor development (especially pertaining to posture) and secondly with the ability to stabilise vision during head movements (Nandi & Luxon, 2008).

Nandi and Luxon (2008) believe that vestibular assessments are imperative in children with profound hearing loss. Vestibular impairment in children with sensorineural hearing

loss is common in profoundly children with deafness. About 20% have complete bilateral vestibular loss (Wiener-Vacher, 2008). The cochlear and the vestibular organs are closely related anatomically and there is a high incidence of congenital vestibular dysfunction in children with congenital deafness. Iinfants and children with congenital deafness commonly suffer vestibular failure in both ears, which leads to impairment of postural control, locomotion and gait. The development of gross motor functions, such as head control, sitting and walking is likely to be delayed in these children (Kaga, Shinjo, Jin & Takegoshi, 2008). Vestibular disorders are also associated with both nonsyndromal and syndromal hearing impairment (Nandi & Luxon, 2008).

Although the cause of the hearing loss for most of the children in the study's sample was unknown, there were children presenting with a hearing impairment for congenital and syndromal reasons (Archer-Swanepoel, 2010a). It is possible for these children to catch up with their hearing peers in terms of development and growth as a result of central vestibular compensation. The visual, somatosensory and motor systems (cerebellum, basal ganglia, cerebrum) and intellectual development compensate for vestibular failure in these infants and children (Kaga, Shinjo, Jin & Takegoshi, 2008). As a result, this condition is particularly difficult to identify (Nandi & Luxon, 2008), and vestibular status cannot be predicted from the behaviour of the child because of the efficiency in compensation when partial vestibular function remains (Wiener-Vacher, 2008). The plasticity of the developing brain in children with congenital vestibular failure can overcome delays in gross motor and balance function, such that the children may develop great skills in exercises and sports activities (Kaga, Shinjo, Jin & Takegoshi, 2008). The diagnosis of vestibular loss must be identified early because prompt physical therapy can reduce the delays of posturomotor control that can be deleterious for other cognitive development (Wiener-Vacher, 2008).

4.2.4.2 The Proprioceptive System and the Term Kinaesthesia

Closely related to the other senses and interdependent upon them is the compound sense of ***proprioception*** (Goddard, 2005:76). It applies to the actual awareness of sensations that come from proprioceptors located throughout the body in the muscles,

joints, skin, tendons, and underlying tissue (Cheatum & Hammond, 2000:185; Goddard, 2005:76). The proprioceptors relay information about the relation of body parts to one another (Rosdahl & Kowalski, 2008:220), and give the body a sense of itself in space (Hannaford, 2005:48). The proprioceptors on the skeletal muscles perceive movement through degree of stretch, angle and relative position of limbs. The proprioceptors on the hands help to detect the shape of objects via touch (Zillmer, Spiers & Culbertson, 2008:181).

The input from these numerous proprioceptors found all over the body is processed largely through the vestibular system. At the same time this information is also matched with information from all the other sensory systems to influence body movements and direct adjustments for fine muscle coordination. Proprioception is the internal sense of physical self which allow one to carry out movements without any conscious awareness and in the absence of other sensory cues. The constant feedback from the proprioceptors to the motor cortex of the brain allows for more complexity of movement. It is understandable that distorted information coming from either the vestibular or the other senses will also affect proprioception (Cheatum & Hammond, 2000:185; Goddard, 2005:76; Hannaford, 2005:49). Children with poorly organised proprioception may have trouble doing anything when they cannot see it with their eyes (Ayres, 2005:41). The proprioceptive, vestibular and visual systems in particular are so intricately related that when one system is not working effectively (or at all), the other two systems can provide sufficient information to the brain to keep the body in an upright position. In this way, blind people can hold their body in an upright position based on the information received from the vestibular and the proprioceptive systems in the body. However, children whose vestibular system is not functioning will usually also have a faulty proprioceptive system and must then rely on their visual system to tell them where they are in space (Cheatum & Hammond, 2000:188). As proprioceptive functioning is directly related to body awareness, problems in this system may block the development of a body schema. As a result the progress through the developmental stages of laterality, directionality and directional discrimination may be hampered (Cheatum & Hammond, 2000:204).

A term often used synonymously with proprioception is ***kinaesthesia***. These two terms are often considered to refer to the same construct (Cheatum & Hammond, 2000:185). However, proprioception, refers to all sensations involving body position, either at rest or in motion, while kinaesthesia refers only to sensations arising when active muscle contraction becomes involved and the actual sensation of the movement in space (Goddard, 2005:76,153). Normally, a combination of vision, vestibular input and the proprioceptive sense supplies a kinaesthetic sense of one's physical body (Zillmer, Spiers & Culbertson, 2008:183, 524). As sound supplements visual, tactile and proprioceptive information about spatial orientation, speed, pressure and sequential movement, auditory deprivation may impede motor development and adaptive movement learning (Schopmeyer, 2009:159).

4.2.4.3 The Tactile and the Auditory Systems

The vestibular and proprioceptive systems tell us what is happening within, whereas touch, hearing and vision tell us about the world outside (Goddard Blythe, 2004:193). Just like the vestibular sensation and touch, hearing is the reception and transmission of energy through motion and vibration (Goddard, 2005:64). Chapter two presented a thorough review of the auditory system and the influence of ***hearing*** impairment on a child's overall development. This subsection focuses on the sensation of touch or the tactile system.

Although the vestibular system is the first to be fully developed and myelinated, it is the sense of ***touch*** which provides us with our first source of contact with the outer world (Goddard, 2005:60), and is the first of all the inside and outside sense to appear (De Jager, 2011:51). It is the thus the earliest sensory system to develop (Goddard, 2011:183).

The first observed tactile response occurs around five weeks after conception (De Jager, 2011:51; Goddard, 2005:60). In the embryo, awareness of and response to touch begins with the mouth. This awareness spreads to the hands and the feet until finally the whole body surface become responsive to touch. At first, this is a purely avoidance

reaction, but withdrawal soon begins to be replaced by some of the grasping reflexes present at birth, and later the ability to touch and let go at will (Goddard Blythe, 2004:193). The earliest primitive awareness of touch is therefore a defensive one characterised by withdrawal (referred to as the withdrawal reflex), and by the time the baby is born, touch is associated with security, feeding and comfort (De Jager, 2011:52; Goddard, 2005:60).

The receptors that sense touch are referred to as tactile receptors and they are found mostly in the skin, covering the entire body (Goddard, 2005:60; Rosdahl & Kowalski, 2008:219). The skin is the largest organ of the body and is brimming with nerve sensors that are continuously receiving nerve impulse for light touch, heavy touch, pressure, heat, cold, pain, softness and proprioception (Hannaford, 2005:44-46). The parietal lobe of the brain, and more specifically the somatosensory cortex (Goddard, 2005:60), is responsible for interpreting tactile stimuli (Rosdahl & Kowalski, 2008:219) (see the review of the somatosensory area in chapter three). Goddard (2011:183) recognises two types of touch receptors: defensive (or protective) and discriminatory. If either tactile withdrawal or grasp reflexes prevail beyond their allotted time, they will disrupt the delicate balance between the protective and the discriminative tactile systems (Goddard, 2005:63). The former acts as a protective mechanism from potentially harmful tactile stimuli by attempting to block the sensation from travelling further into the NS, while the latter allows information received through touch to enter deeper into the NS to be processed and integrated with information received from other senses (Goddard, 2011:183). Touch precedes both hearing and vision as the primary channel of learning (Goddard, 2005:60). Later on, this tactile knowledge will be transferred to the senses of sight and hearing, to the understanding of spatial relationships and object constancy (Goddard Blythe, 2004:194). Children who have an overactive protective system will be “tactile defensive” and may still have uninhibited cutaneous withdrawal reflexes which continue to influence the CNS (Goddard, 2005:60). They find touch irritating and painful and will avoid contact (Cheatum & Hammond, 2000:240). Children can be over-sensitive (hypersensitive) or under-sensitive (hyposensitive), or have a combination of both to touch sensations. A larger number of touch receptors are found in some areas,

such as around the lips or on the fingertips (Hannaford, 2005:46). Hypersensitivity is thus expected to occur more often in these areas, resulting in tactile sensitivity to food textures and a possible inability to demonstrate a correct pencil grip (Van der Westhuizen, 2007:142).

As the sense of touch is also important for the formation of an internal 'map' of where parts of the body are in space, and ultimately a body image, issues related to touch sensitivity can sometimes present as clumsiness, poor sense of body image, avoiding people's touch or closeness or an abnormally high or low threshold for pain (Goddard, 2005:61; Goddard, 2011:183). Even before birth, stimulation to various parts of a foetus starts to build an awareness of body schema, and the first connections between a baby's skin, brain and muscles are wired (Cheatum & Hammond, 2000:226; De Jager, 2011:52). Ultimately, touch enables a child to form a stable foundation for a positive body image, which in turn leads to emotional and social development (Cheatum & Hammond, 2000:226).

We know that physical deprivation in the early years can result in problems with emotional regulation, reciprocal interaction and attachment (Goddard Blythe, 2004:194-195). When touch is lacking, children and adults exhibit depressed motor and mental functioning (Hannaford, 2005:45). The absence of touch may slow nerve development to such an extent that essential bodily function development may not occur and death ensues (Hannaford, 2005:46). Infants massaged regularly have been found to have significantly better neurological development and mental functioning (Goddard Blythe, 2004:194-195). Merely the act of being touched increases production of a specific hormone within the brain that stimulates axon growth and nerve development (Hannaford, 2005:44). Interactions that include a great deal of touch, play and being fully present may be central for cognitive development (Hannaford, 2005:46), as "hands-on" experiences or manipulatives during the learning process greatly increase learning efficiency (Hannaford, 2005:47). This is because whenever touch is combined with the other senses, much more of the brain is activated and more complex nerve networks are built as a result. More learning potential is therefore reached (Hannaford, 2005:47).

According to Brack (2004:5-6), vestibular input stays in the NS for four to eight hours, and proprioceptive and tactile information for up to one-and-a-half hours. More general rough and tumble play is also important because it not only boosts integrated functioning of the different sensory systems, but also recruits and exercises brain areas and abilities from the brainstem at the base of the brain right up to the somatosensory cortex at the top. This promotes general physical fitness and helps to teach regulation of strength and self-control within social settings. It improves general proprioceptive awareness (Goddard, 2011:184).

Training in the use of all the other senses helps the child with hearing impairment to better use any available hearing (Timby & Smith, 2005:148). At the school where the sample was taken, it is obvious that most of the children and the teachers used touch and vision as a mean to communicate effectively. A first step in communicating with the Deaf is to gently touch them on the shoulder or arm to get their attention. Other ways to gain their attention are to tap on the table where they are sitting or stamp your feet on the ground close to where they are standing. The vibrations produced by the tapping or stamping are picked up by the hearing impaired. In a signed conversation, it is important to maintain eye contact, as looking away is often indicative that the conversation has ended (Grayson, 2003:20; Mudgett-DeCaro, 1996:286; Sharma, 2006:181). The speech therapist at the sample school often uses the children's sense of touch during music lessons. During this class, music is played loudly over special speakers mounted into a wooden stage. The children dance to the vibrations felt on the stage (Archer-Swanepoel, 2010b). The researcher relied particularly on the participant children's senses of touch and vision during both the assessment phase of the study and the programme implementation phase. A more detailed discussion of this follows in later chapters.

4.2.4.4 The Visual System

Vision plays an enormous role in helping a child to develop cognitive, social and motor skills (Kurtz, 2006:21). Visual images received through the eyes provide 80% to 90% of the information that the brain receives. If children experience vision problems, they will

receive distorted views of most of the information going to their brain. When these inaccurate images are then combined with information from the vestibular, tactile, proprioceptive, and auditory systems, the information can be mildly to severely disorganised. This will interfere with a child's ability to learn (Cheatum & Hammond, 2000:263). Cheatum and Hammond (2000:266) and Goddard (2005:73) go on to explain that images gained through the eyes depend on a pathway known as the vestibular-ocular reflex arc (VOR). This is because the balance mechanism in the inner ear and the muscles which control eye movements operate from the same circuit in the brain – the VOR. Problems with automatic balance will affect eye movements and vice versa (Goddard Blythe, 2000). The VOR combines images received from the eyes with information received from the other sensory systems. The VOR is a response that makes it possible to sustain visual fixation on a target no matter how the head is moved (Kokot, 2010b). Kokot (2010b) clarifies that this is made possible by input from the vestibular system that generates an equal but oppositely directed eye movement that corresponds to the speed of the head movement. When there is interference with the information received from the vestibular system, the eyes, and the level of reflex response, functioning of the VOR is reduced and may even be lost. This may cause blurred vision when a child moves his or her head or body. Damage to any one of the semicircular canals of the vestibular system will also result in a distorted image (Cheatum & Hammond, 2000:266).

By now it should be clear that all the sensory systems are important for every day optimal functioning, and that these systems are highly interdependent. A structural outline of the visual system now follows, commencing with the early development of this sense.

The visual system has three distinct parts: 1) the organs of sensation, which are the eyes; 2) the optic nerves, which transmit visual images from the eye and transport them to the brain; and 3) the visual cortex, which is the part of the brain responsible for interpreting information received via the optic nerves. These three parts are interdependent so that problems in one area may impact another and influence a child's

visual perception (Kurtz, 2006:15). The foundation of a baby's visual system starts to develop only three weeks after conception when two large bubbles form and deflate to become the left and the right eye. At five weeks after conception each eye already contains a retina and a lens. By eight weeks after conception the eyes look like normal human eyes and are protected by fused eyelids (De Jager, 2011:113). As early as 12 weeks after conception the eyes begin preparing for their role by practising the muscular movements that will allow for the eyes to focus on their world after birth (Kurtz, 2006:21). Although the visual system is anatomically mature at birth, the infant does not see things in the same way as an older child or an adult (Kurtz, 2006:21). A newborn can only see clearly up to a distance of about eight inches – roughly the distance between the baby and his or her mother's face (Cheatum & Hammond, 2000:266). As there is no light in the womb, the eyes are far less developed in terms of functionality than any of the other senses at birth. It also has the biggest 'map' to wire and takes several years to reach its full potential (De Jager, 2011:113). The visual system therefore proceeds through a tremendous developmental maturation process as the child experiences and learns from visual input (Kurtz, 2006:21).

De Jager (2011:117) indicates that an infant's sense of sight gets a strong boost at around 18 weeks after conception when the ATNR starts to appear (see the primitive reflex profile in figure 3.12). The ATNR prompts baby's arm and leg on the same side of the body to straighten whenever the head is turned to that side (De Jager, 2011:117). Although it is dark in the womb and foetuses cannot see their facing hand (De Jager, 2011:117), the ATNR provides the continuous motion which stimulates the vestibular system, increases neural connections, and is the first eye-hand coordination that takes place directly after birth (Goddard, 2005:10-11). However, an aberrant ATNR can negatively affect eye movements in that the tracking ability (***ocular motility***) of the eyes can be impaired (Goddard, 2005:11, 73). Between birth and ten weeks baby should be able to see with greater clarity (De Jager, 2011:120).

The eye is referred to as the organ of vision and lies in a ball-shaped cavity of the skull called the orbit (Rosdahl & Kowalski, 2008:213). Figure 4.3 illustrates the major

structures of the eyeball. It is a hollow sphere that consists of three layers of tissue. The *sclera* is the tough ***protective outer layer*** around the eyeball, also often referred to as the 'white' of the eye. The *cornea* is the structure through which light rays pass and is the section over the front of the eyes. The cornea is very sensitive to touch and pain and even a minor irritation will stimulate a blinking reflex. The ***middle layer***, the *choroid,* is vascular and brings oxygen and nutrients to the eyes. Over the front of the eye, the choroid develops into a pigmented section, the *iris*, which gives the eye its specific colour (Cheatum & Hammond, 2000:264; Rosdahl & Kowalski, 2008:214).

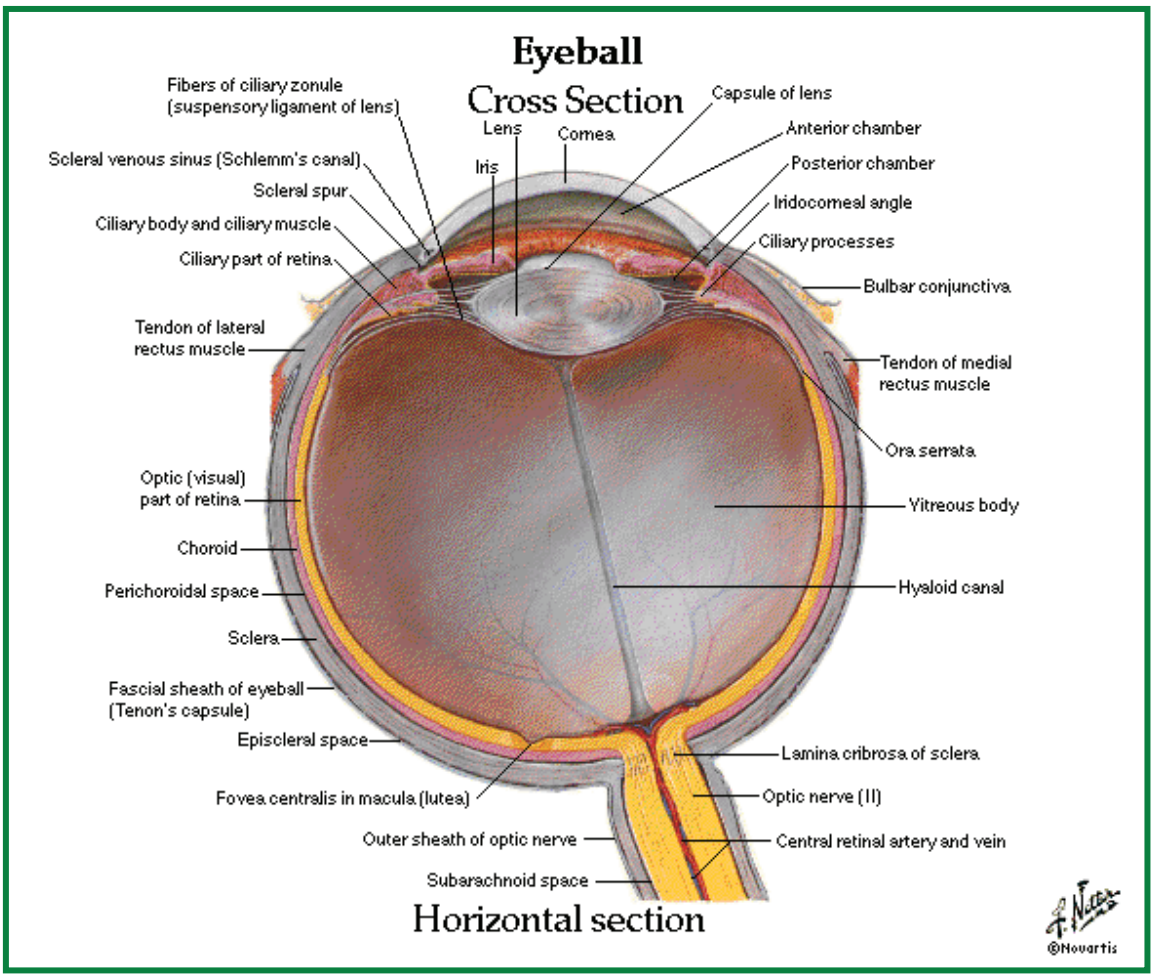

Figure 4.3 The Human Eye

(Novartis, 1999)

The choroid extends to the *ciliary* body. The ciliary contains muscles that adjust the

shape and the thickness of the *lens*. This is to allow the eye to focus on objects close up or far away by projecting the images clearly onto the retina. This process is described as ***accommodation***, and specifically refers to the ability of the visual system to adjust to a change in distance. The eyes thus remain in focus when objects move towards or away from them or when they shift their gaze from objects close to the face to those at a distance. ***Convergence*** occurs when people focus on an object near their face or one that is moving toward their face. As the object moves closer to the face, an increased amount of stress is placed on the eyes to maintain a single image. This results in the eyes starting to move toward the nose to help maintain focus. ***Divergence*** refers to the ability to focus on an object at a distance or as it moves away from the face (Cheatum & Hammond, 2000:265, 267; Kolb & Whishaw, 2009:207; Kurtz, 2006:17; Rosdahl & Kowalski, 2008:214).

The *anterior chamber* is the space between the cornea and the lens and in front of the iris. The *posterior chamber* begins behind the iris. There are muscles in the iris that controls the size of the *pupil*. The pupil is the black centre opening within the eye that regulates the amount of light that enters the eye. The *lens* is located behind the iris and plays a major role in focusing the light rays on the retina. The ***inner layer***, the *retina*, contains the receptors for the optic nerve. It also contains specialised neurons, called rods and cones, which permit the perception of light, dark and colour. The retina records the images it receives in an upside down and reversed format and changes the images into nerve impulses (Cheatum & Hammond, 2000:265; Kolb & Whishaw, 2009:207; Kurtz, 2006:17; Rosdahl & Kowalski, 2008:214; Wilson-Pauwels *et al*., 2010:32). ***Visual acuity*** is a term used to describe the acuteness or sharpness of the image striking the retina. It is the ability to see clearly and is also referred to as sight (Cheatum & Hammond, 2000:266).

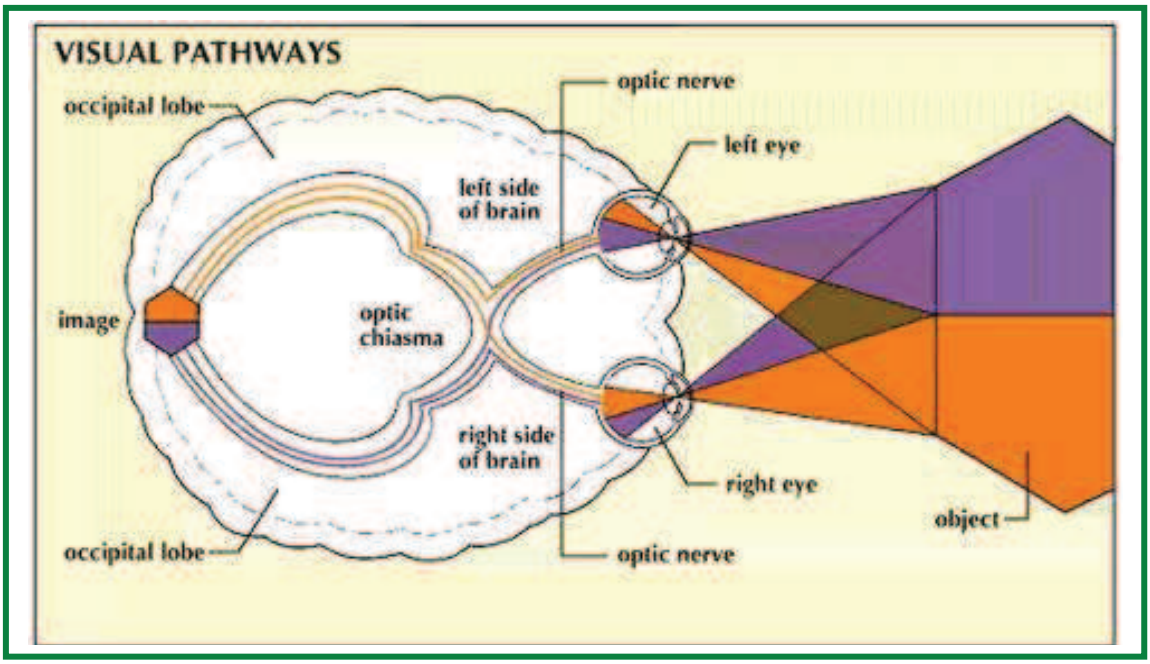

Figure 4.4 Visual Pathways

(The Learning Company, Inc., 1997)

Several cranial nerves and groups of muscles are involved in eye functioning and in the transmission of impulses from the eye to certain brain centres. An overview of the cranial nerves was given in the preceding chapter (see table 3.2). The second cranial nerve, *the optic nerve* (see figure 4.4) carries the stimuli for vision from each eye. The stimuli from both eyes meet at the optic chiasm, where some of the optic nerves cross and then continue as the *optic tract*. The optic tract conducts the stimuli from both eyes to the brain's occipital lobes in the central cortex. The left side of the occipital lobe receives visual images from the right side of an object and the right side of the occipital lobe receives visual images from the left side of an object. This means that the right half of each eye's visual field is represented in the left hemisphere of the brain, and the left half of each eye's visual field is represented in the right hemisphere of the brain. In this way each eye is able to send information to both the right and the left sides of the brain (Kolb & Whishaw, 2009:207-208; Kurtz, 2006:18; Rosdahl & Kowalski, 2008:214).

A branch of the fifth cranial nerve, the trigeminal nerve (the ophthalmic nerve), carries sensations of eye pain and temperature to the brain. Three pairs of outside muscles attached to its outer coat and connected to the top, bottom and sides of the sclera move

the eyeball. These six muscles allow the eye to move in all directions in order to take in visual information from a large field as well as from moving targets. They also ensure that the eyes work together in a well-synchronised manner, a process known as ***binocular*** vision. Binocular fusion refers to the ability of the visual system to blend the images received from the two eyes into a single image. Another muscle, attached to the upper eyelid, holds the eye open. The third cranial nerve, the oculomotor nerve, innervates some of the voluntary muscles that move the eyeball and the eyelid, and is also involved in pupil accommodation. The fourth cranial nerve, the trochlear nerve, assists with some voluntary eyeball movements. The sixth cranial nerve, the abducens nerve, coordinates with cranial nerves three and four to move the eyes. All of these muscles play a vital role in visual tracking or ***ocular motor tracking***. This refers to the visual system's ability to follow or track moving objects, or when the eyes move across a page while reading. The term ocular motor control refers to the ability to use the six eye muscles that allow the eyes to move in all directions for tracking (Cheatum & Hammond, 2000:264, 267, 269; Kurtz, 2006:17; Rosdahl & Kowalski, 2008:215; Wilson-Pauwels, 2010:56). This tracking ability does not only depend on the muscles and the cranial nerves that service the eyes, but also on information and regulation from the vestibular system (Ayres, 2005:63; Kokot, 2010b).

The brain ultimately interprets the images received from the eyes through a process referred to by several terms, including visual perception, visual cognition, or visual information processing (Kurtz, 2006:11). For clarity, the term visual perception will be used throughout this report to refer to the brain's interpretation of visual input. How the person sees, the way that the eyes are used, and the perception of the world through sight, are the result of a complex series of connections and neural developments which take place in the early formative years, and which are dependent upon adequate maturation of the CNS (Goddard, 2005:70). Cheatum and Hammond (2000:267) explain that visual perception depends on several visual skills. These include binocular fusion, accommodation (convergence and divergence), fixation, visual pursuit, depth perception, visual memory, and visual sequential memory. Difficulties with either accommodation or convergence can affect one another. Smooth tracking is important

so that the brain can receive a flow of sequentially correct information (Goddard, 2005:71). Poor control of eye movements can mean the brain receives 'scrambled' information, which in turn may lead to reading difficulties, for example (Goddard, 2011:181). It was mentioned before that an aberrant ATNR can have an adverse effect upon tracking, as can an aberrant TLR upon convergence and an aberrant STNR upon the readjustment of binocular vision between near and far (Goddard, 2005:73). This accentuates not only the importance of integrated primitive reflexes, but also the interrelatedness of early neurological development, optimal maturation of the sensory systems, and academic, social and physical skills in later life.

The quality of a child's vision and visual perception affects all aspects of a child's physical, intellectual, emotional, and social growth (Kurtz, 2006:11). A child with deafness greatly depends on sight not only to determine the environment, but also to communicate. It is a critical sense for a child with deafness (Timby & Smith, 2005:148). The sensory compensation hypothesis suggests that because children with deafness lack hearing, they are principally proficient in the visual domain, and that this advantage presumably increases over time and with visual experience (Marschark, 2003:466). In contrast, the deficiency hypothesis states that impairment in one sensory system adversely affects the others as a consequence of the interdependence of all sensory systems. Marschark (2003:473) believes that deaf and hearing individuals consistently show both similarities and differences in their performances and that individuals with deafness show an advantage relative to hearing peers in several domains of visuospatial processing, but primarily as a function of their experience using a signed language.

Research done in the early nineties examined the relationship between auditory information and movement coordination. One study examined children with hearing impairment's ability to catch a ball approaching from the outside of their view-field using various angles and measuring reaction times (Savelsberg, Netelenbos & Whiting, 1991). The results indicated that children with deafness had more problems catching a bouncing ball in comparison to their hearing counterparts when the ball was completely

in sight. Children with hearing impairment showed lower performance and longer reaction times than the control group. The results indicated the importance of auditory stimuli in visually oriented movement coordination (Savelsberg, Netelenbos & Whiting, 1991).

Later research confirmed that auditory stimuli play an important role in the direction of visual movements in orienting the eyes, the head, and the body in the environment (Erden, Otman & Tunay, 2004). A study with 40 severely bilateral sensorineural children with hearing impairment between the ages of eight and ten years were compared to a hearing sample and evaluated in terms of their visual perception The sample with hearing loss had lower scores compared to their age-matched hearing peers in all visual perceptual tests (Erden, Otman & Tunay, 2004). In another study, 279 children with hearing impairment between the age ranges of five to twenty years were assessed for ocular abnormalities. It was found that the children with hearing loss had an increased risk of having ocular abnormalities. Periodic eye examinations were stressed as being very important in children with hearing loss as the early identification and correction of oculo-visual abnormalities may help increase a child with a hearing disability's quality of life (Bist, Adhikari & Sharma, 2010). Peripheral vision development in children with profound deafness without cochlear implantation was compared to age-matched hearing controls, as well as to deaf and hearing adult data. The sample included children between the ages of five and fifteen years and all participants had good visual acuity in both eyes. The study found reduced peripheral vision in children with deafness between five and ten years of age. However, these differences diminished throughout childhood. Children with deafness performed equally to hearing children aged eleven to twelve years, whereas adolescents with hearing loss (aged thirteen to fifteen years), demonstrated faster reaction times to all peripheral stimuli in comparison to hearing controls. Results for adolescents were consistent with deaf and hearing adult performances in that adults with hearing impairment showed significantly faster reaction times than hearing controls. Visual compensation for deafness is thus first evident in the reaction times of adolescents with hearing impairment aged thirteen years old (Codina, Buckley, Port & Pascalis, 2011).

Another study worth citing tested the visual working memory of a group of 50 children with severe to profound deafness (mean age 11 years) with different communication modes. Hearing controls were used to compare performance. The study concluded that the communication mode is an important variable. Children with deafness using both oral language and sign language (bilinguals) outperformed those using only sign language or oral modes of communication on the accuracy measures. Deaf groups with either oral or sign language modes of communication completed the tasks with less accuracy than both the hearing controls and the bilinguals (Lopez-Crespo, Daza & Mendez-Lopez, 2012).

The discussion on the visual system concludes this overview of the sensory-motor systems. This section intended to provide an outline of the most important sensory systems for developing learning readiness through movement. Goddard (2005:160) states that only when both motion and sensation are integrated can the higher language skills of speech, reading and writing develop fluently. She adds that it is through movement that further connections are made between the vestibular apparatus and higher centres of the brain (Goddard, 2005:159). The next section paves the way for a consideration of the integration of the basic neurological subsystems and the importance of movement.

4.3 THE INTEGRATION OF NEUROLOGICAL SUBSYSTEMS AND MOVEMENT

It was repeatedly shown in the preceding sections that the senses do not develop or operate in isolation. They depend on each other to interpret information and movement (Cheatum & Hammond, 2000:127). The ability of the brain to integrate input from the various senses in order to respond appropriately and automatically was also highlighted. Another central component to sensory processing is ***modulation***. This refers to the brain's regulation of sensory input. Modulation instantly adjusts and balances the flow of sensory input coming into the CNS (Ayres, 2005:36, 62; Kranowitz, 2005:87). A neurological process named ***inhibition*** allows the brain to filter out useless information and focus on what matters. Without inhibition people would be very distractible and would focus on every single sensory input, whether that sensation is useful or not

(Ayres, 2005:36; Kranowitz, 2005:57, 312). Kranowitz (2005:64) goes on to explain that not one part of the CNS works on its own. Messages must continuously go back and forth from one part to another. When sensory information is received in an appropriate manner, appropriate motor messages can go out, and as a result one can function efficiently and do what one needs to do (Kranowitz, 2005:64). Goddard (2005:160) illustrates this by stating that the eyes operate from the vestibular circuit in the brain. The ears share the same cranial nerve. The sense of touch is integrally linked to the vestibular system through the movement across hair cells whose receptors are located in the dermis of the skin.

The Holistic Approach to Neurodevelopment and Learning Efficiency ***(HANDLE®)*** Institute in California (United States of America), offers a diagrammatical representation (refer to figure 4.5) of the integrated and interdependency of the subsystems required for effective functioning (HANDLE®, 2011). The institute offers therapeutic aid for clients with a wide variety of functional difficulties in overcoming problems causing learning and/or attentional difficulties (Kokot, 2005). It is ultimately an approach designed to enhance neurological systems that are causing learning or life difficulties (HANDLE®, 2011).

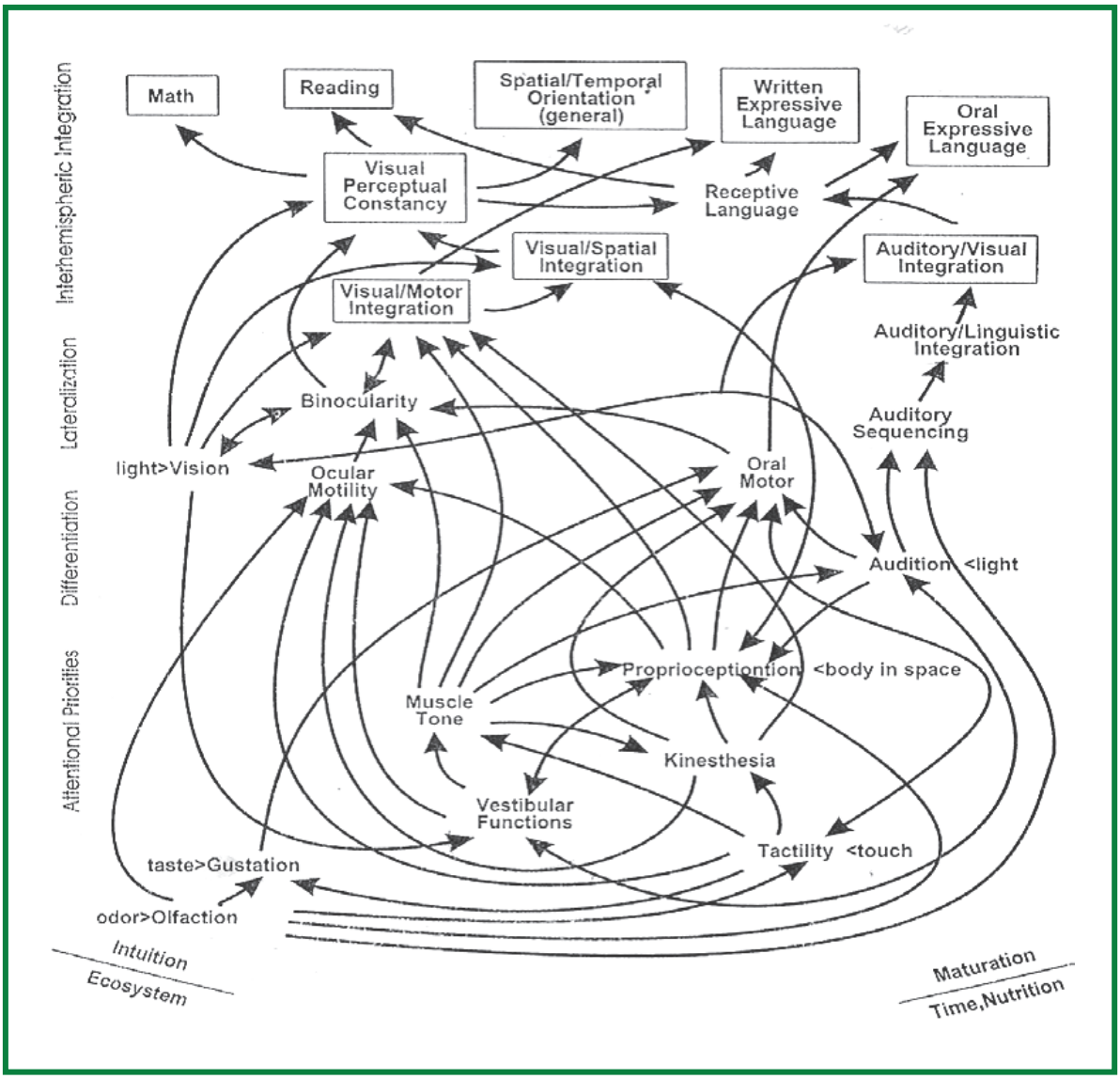

Figure 4.5 Sensory-Motor Interdependency and Interaction

(Bluestone, 2005)

This chart was developed by Judith Bluestone (2005), the director of HANDLE®. It illustrates the hierarchical nature of the neurological system and indicates how higher level systems depend on the systems at the lower level. For example, problems with reading may be traced all the way back to a dysfunctional vestibular system (Kokot, 2005). The chart also points out the hierarchical nature of human development from bottom to top. The interdependency and interaction between the different neurological subsystems are indicated by arrows, and reminds us that nothing stands alone in

neurological functioning (Kokot, 2005). The arrows furthermore indicate that the different subsystems support others while being supported by those below them. Systems higher up could also have an effect on the systems below them. No subsystem can function on its own. A weakness in a particular subsystem places strain on all the other subsystems due to their interconnectedness (Van der Westhuizen, 2007:179-180).

Of further significance is that the integrated approach offers possible clues for an intervention programme which should start at the root, and gradually develop and structure the neural networks which support the cortical systems (Van der Westhuizen, 2007:180). Lowest-level systems should therefore be addressed first. As these systems are then strengthened, the higher-level systems can benefit optimally from the intervention programme (Kokot, 2005). Kokot (2005) adds that it would be pointless to address higher-level systems before strengthening the weakened foundational systems, as such an approach does not resolve the causal issue and leaves the weakness to affect other skills.

A comparable approach is used by an Australian provider of information and products to enable people to overcome learning difficulties, named ***Move to Learn***. The Australian educator and pioneer in the field of developmental movement programmes, Barbara Pheloung, is the founder of *Move to Learn.* She illustrated '*The Ladder of Learning*' (see figure 4.6) to explain the order of the stages for neurological development (Mountstephen, 2011:72; Move to Learn, 2012a; Pheloung, 2006:2).

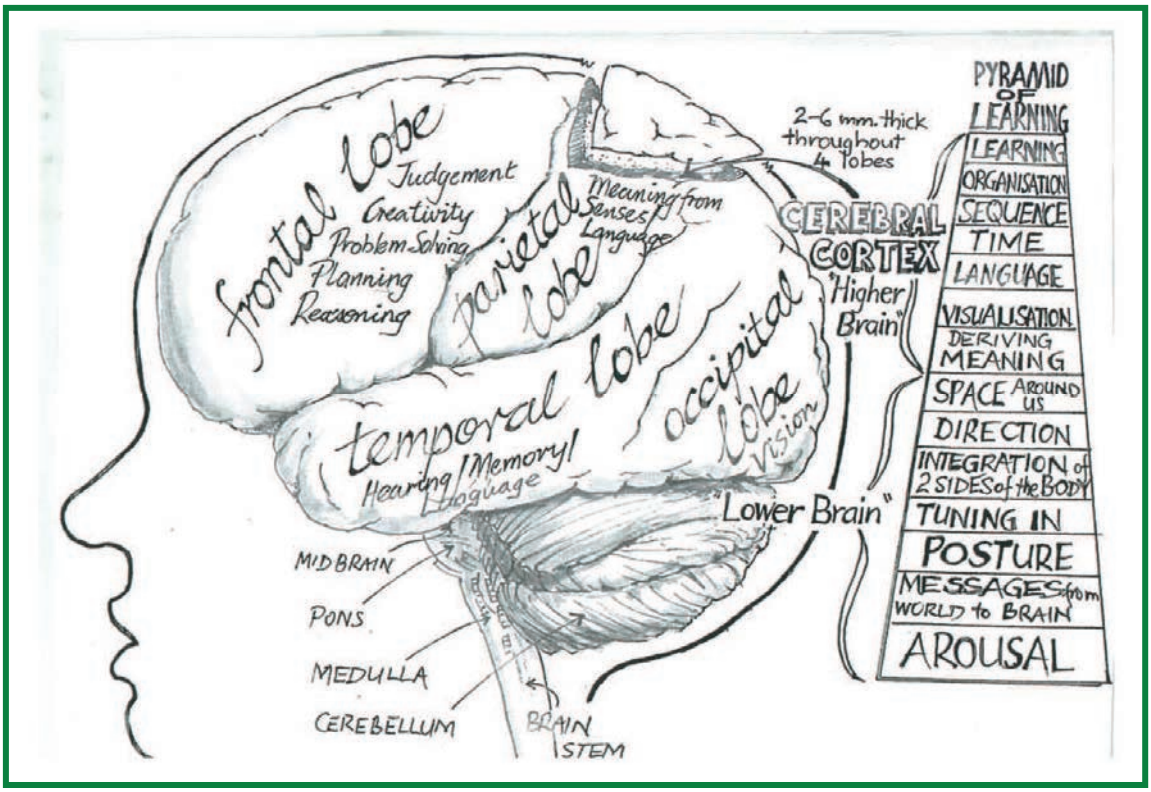

Figure 4.6 The Ladder of Learning

(Pheloung, 2006:2)

Figure 4.7 offers a schematic representation of the same idea. Each stage of neurological development is foundational for the following stage and must be in place for learning to be accomplished successfully and enjoyably (Move to Learn, 2012b). The skills a child needs to read and write are at the top of the pyramid. If the bottom layer of the pyramid has not been properly built, the top layer of the pyramid cannot function flawlessly.

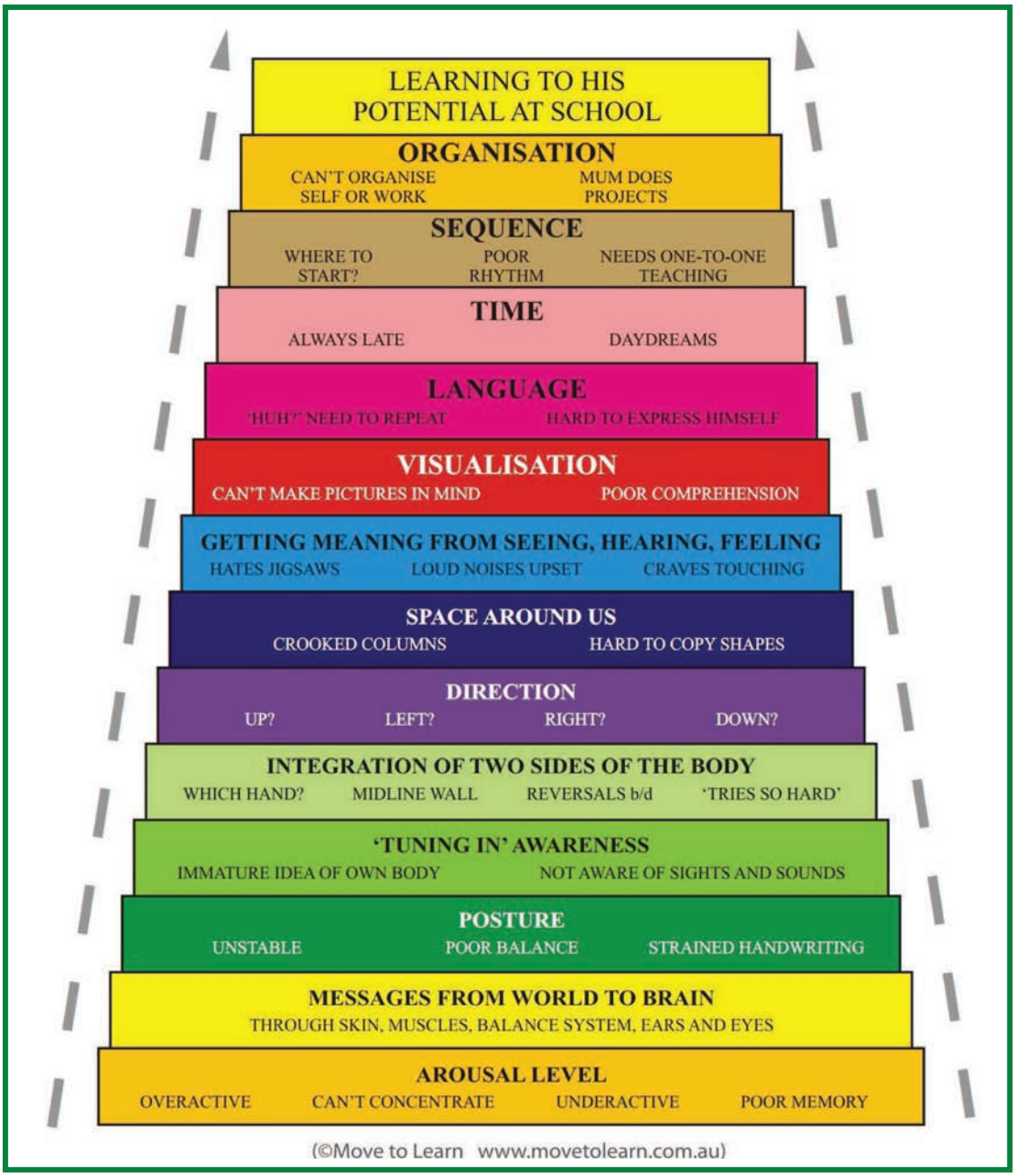

Figure 4.7 The Pyramid of Learning

(Move to Learn, 2012b)

Two South African educational psychologists, Professor Shirley Kokot and Dr. Beulah van der Westhuizen, both with a specialised interest and international training in the field of neurodevelopment, have integrated additional neurodevelopmental theory, as well as the ILT (2010b) approach, with the original HANDLE® diagram to construct an interrelated systems chart (figure 4.8) (Kokot, 2012). Professor Kokot is the founder of a

South African based centre for ***Integrated Learning Therapy (ILT)***, which brings together knowledge and practice from related fields with the focus on the development of the NS (ILT, 2010b). Dr. Van der Westhuizen is the initiator of a Pretoria based private therapeutic and remedial school called ***Edu Excellence***, which offers assistance to children with concentration difficulties (Van der Westhuizen, 2012).

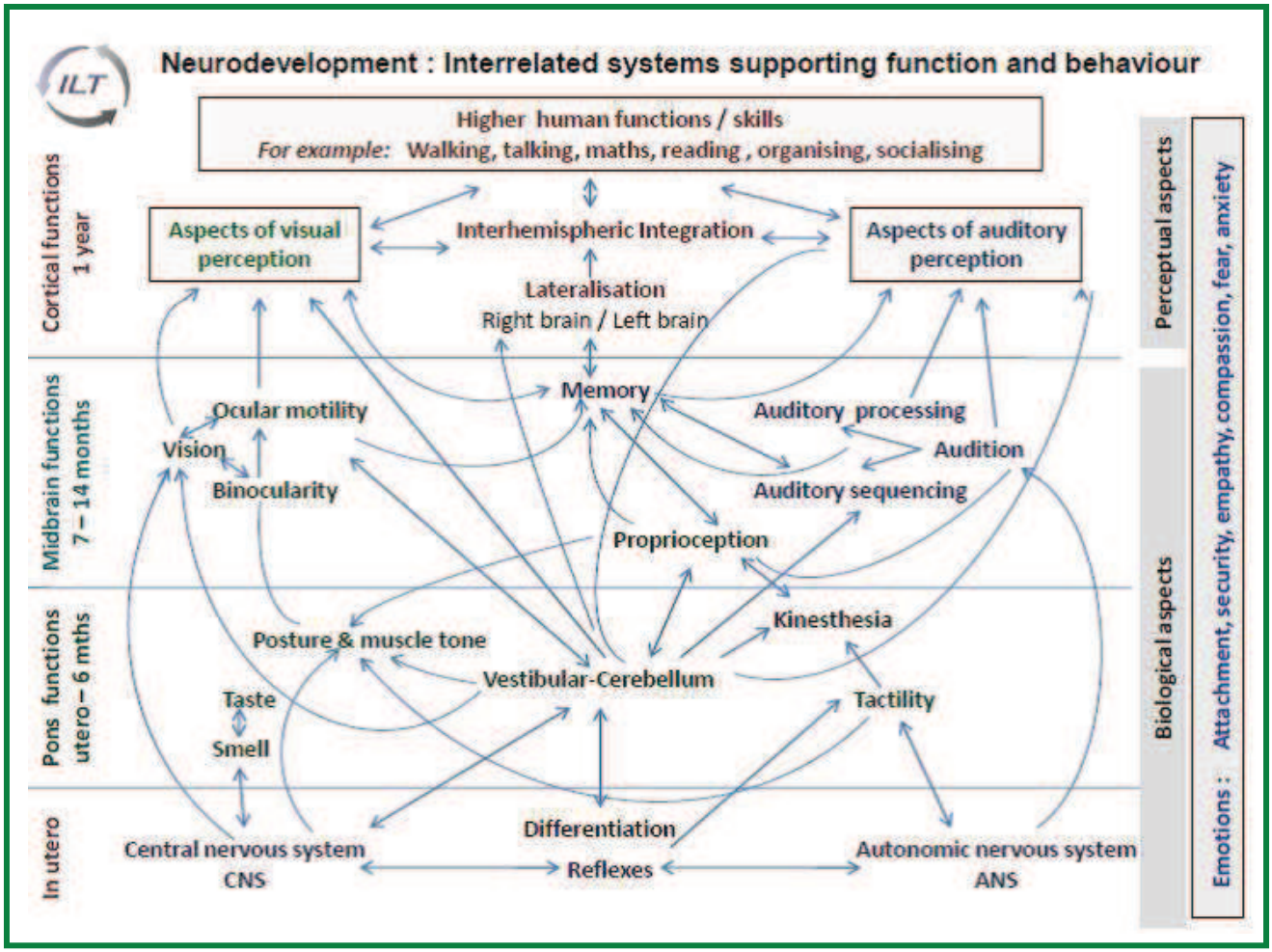

Figure 4.8 ILT: Interrelated Systems Chart

(Kokot, 2012)

Like the HANDLE® diagram (compare figure 4.5 and figure 4.8), the ILT interrelated systems chart illustrates the hierarchical nature of the neurological system and indicates how higher level systems depend on the systems at the lower level. The arrows similarly indicate that the different subsystems support others while being supported by

those below them. Approximate ages are introduced in this chart and come largely from the early work of educational psychologist Carl Delacato (1963). Delacato asserted that humans progress through a fairly consistent developmental pattern. Newborn infants appeared to be generally controlled at the level of the medulla, and reflex action is aimed at survival. At about four months of age, development of the pons appears, and by 10 months, neurological development is at the midbrain level. Neurologically, the one year-old child shows development of an early cortex. The end result of the developmental process is a state of neurological organisation (Delacato, 1963:62, 108; Kavale & Mostert, 2004:147).

Knowledge of the interdependence of the subsystems is fundamental for the optimal functioning of the child. Ignorance thereof leads to a lack of understanding of the role of movement as the basis of all learning, and an upside down approach which concentrates on higher-level functions over instead lower-level ones. The next section takes a closer look at the role of movement in preparing the child for learning.

4.3.1 The Importance of Movement and Learning

The importance of ***movement*** in the neurological development of the child was identified in the previous chapter. It was noted that the early infant's reflexive movements form the basis for neurological development, which occurs before birth until around five years of age. It was also indicated that foetal movement inside the womb and after birth shapes and develops the brain and the body. Figure 4.9 illustrates the first five years of a child's life to be of particular importance when it comes to synaptic formation in the developing brain.

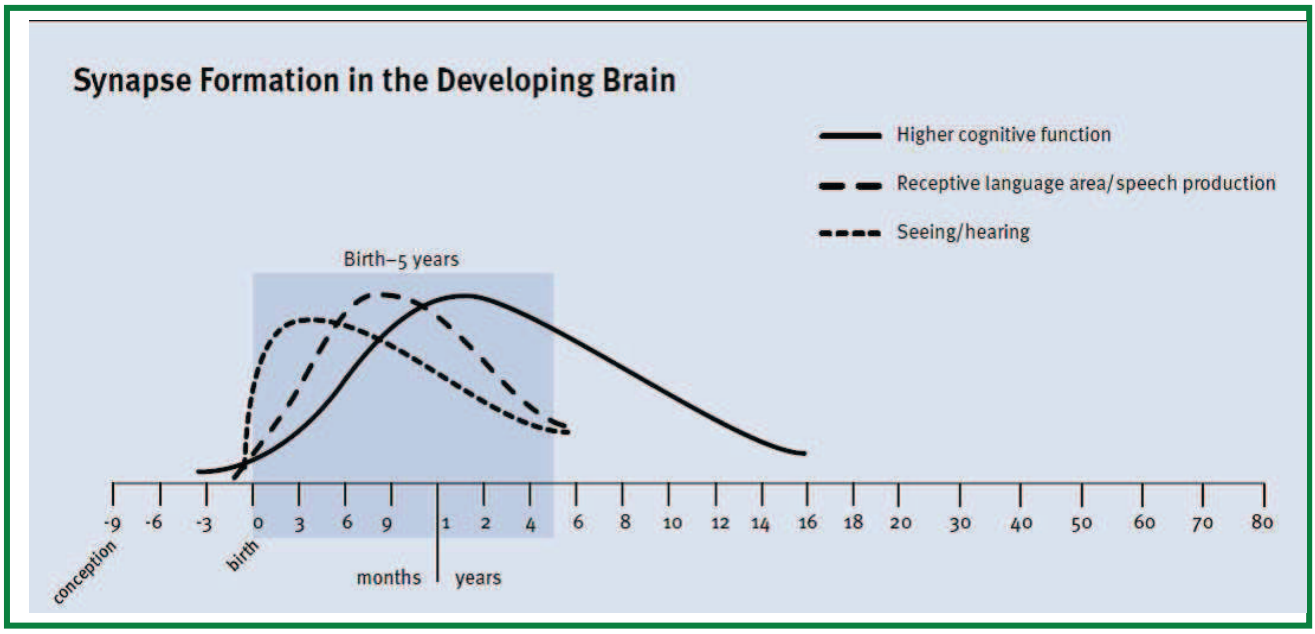

Figure 4.9 Synapse formation in the Developing Brain During Sensitive Periods of Development
(National Scientific Council on the Developing Child, 2007:3)

Prechtl, Einspieler, Cioni, Bos, Ferrari and Sontheimer (1997) studied the fidgety movements of 130 normal awake infants and compared their findings with assessments of neurological development repeated at intervals until the age of two years. The aim of the study was to test the predictive value of absent or abnormal spontaneous movements in young infants for the later development of neurological deficits. The study found that 96% of infants who had normal fidgety movements had a normal neurological outcome, whereas abnormal quality or total absence of fidgety movements was followed by neurological abnormalities in 95% of infants studied. A similar study was conducted in South Africa with a sample of 115 very low and extremely low birth weight infants at the Tygerberg Children's Hospital in Cape Town. The objective of the study was to determine whether the qualitative assessment of fidgety movements at three months corrected age predicts the neurological motor outcome at 12 months corrected age. A significant relationship was found, with the absence of fidgety movements predicting the development of cerebral palsy with 71% of the participants (Burger, Frieg & Louw, 2011).

A working paper by the National Scientific Council on the Developing Child by Harvard University in Cambridge states that an environment deprived of appropriate sensory stimulation results in faulty brain circuitry. Such faulty circuitry could affect further brain development (National Scientific Council on the Developing Child, 2007:1). A relevant finding is that lower level circuits require optimal experiences in order for the higher level neural circuits to carry out sophisticated mental functions (National Scientific Council on the Developing Child, 2007:3-4). This finding supports the hierarchy indicated on the HANDLE® Institute chart, the Move to Learn diagram, and the ILT interrelated system chart (see figures 4.5, 4.6, 4.7 & 4.8). We may conclude therefore that infants and young children not only need sensory stimulation during sensitive periods of neurological development, but more importantly, require stimulation that facilitates movement and processing thereof.

Melodie De Jager, the founder of the ***BabyGym®*** and ***Mind Moves®*** Institutes in Johannesburg (South Africa) explains that every instant in a baby's life involves movement. Cells that are dividing after conception, the heartbeat, the withdrawal and moro reflexes, sucking a thumb, the first kick in utero, breathing, suckling and rolling, are all movement activities that indicate that the brain and the body are developing (De Jager, 2011:139). De Jager (2011:140) adds that every movement of the young infant creates new wiring in the brain. The brain's wiring is structured through repeating the same movements and is pruned when movements are not repeated and the wiring is dissolved. It seems that every healthy child is born with the necessary material needed for the natural ability to cope with school-related tasks, but that these only become effective when children move and act, explore and control, see and describe, hear and attend, as well as feel and respond.

The previous chapter emphasised the importance of an infant's first reflexive responses. These reflexive movements give way to general movements such as crawling, walking, and jumping, and to more controlled actions such as the use of specific body parts to manipulate objects. Reflexes also assist the development of all the senses. Reflexes do not disappear, but rather are integrated with the higher nerve centres of the cerebrum

(Hannaford, 2005:111). Basic motor skills must be practised and refined so that more advanced and finer controlled movements such as handwriting and eye movements for reading can easily occur. With increased physical development, improved messages flow to the brain from all the senses. Coordination, body awareness, balance and the matching of motor sensory input (integration), lateralisation, speech maturity, visual perception and motor planning are the result of development and refining body movement (Hannaford, 2005:107-110).

De Jager (2011:140) draws attention to the link between the way in which babies reaches their motor milestones and their ability to learn. She elaborates that when a baby skips a milestone or reaches a milestone out of sequence (such as walking before crawling), it can create a weakness in the wiring, which may influence future learning. Later movement activities such as the ability to balance on one leg, sitting still, concentrating, holding a pencil, reading and writing also indicate whether all is well or not (De Jager, 2011:139). Movement therefore does not only structure the brain, but is also an expression of the level of structure (Van der Westhuizen, 2007:82). Movement actions are thus the foundations and building blocks for learning; and this relationship between movement and learning continues throughout life. Underlying sensory integrative problems are therefore interrelated with previous developmental stages that have not matured properly. Children whose CNS has not developed in the normal manner, and so are less able to organise a response, are more likely to experience learning difficulties.

Numerous professionals in the field of education and learning strongly concur that both movement and the interactive relationship between the brain and the body determines learning success (e.g., Bluestone, 2005:88; Cheatum & Hammond, 2000:21, 191; De Jager, 2011:139; Goddard, 2005:47; 2011:8; Goddard Blythe, 2004:4; Hannaford, 2005:107; Kokot, 2005; Kranowitz, 2005:31, 156, 185; Mountstephen, 2011:72). This view is supported by the school-based programmes of the ***Institute of Neuro-physiological Psychology*** (INPP, 2011) in Chester in the United Kingdom, and the Move to Learn programme of Barbara Pheloung in Australia (Move to Learn, 2012b).

Pheloung (Mountstephen, 2011:72; Move to Learn, 2012b) observes that much preparation is needed before a child is ready for effective academic learning. Most of this occurs through natural movements and play that are common for all children. While moving through each developmental motor milestone (such as rolling over and crawling), each child is not only learning, but also preparing to learn. Bluestone (2005:88) states that movement and life are synonymous and that movement is necessary for learning. Kokot (2005) elaborates on the importance of physical movement to neural organisation. She notes that movement is essential for the optimal development and functioning of neurological systems. Certain movements can help to reorganise an underdeveloped brain. Fredericks *et al*. (2006) report that the body is a sensory-motor response system as it causes the brain to learn and thus to organise itself. Hannaford (2005:107) believes that movement not only awakens and activates mental capacities, but also integrates and anchors new information and experiences into one's neural networks. Moreover, one of the ways a child learns to regulate their different neurological systems is through movement. These movement patterns need to be utilised and practised over and over again, first reflexively and spontaneously, and later voluntarily and with an ever-increasing range of control (Goddard, 2005:47).

Two important questions regarding the use of movement to enhance neurological systems and their functioning often occur in practice:
1) What to do if the lower level circuitry is not functioning properly?
2) Will any movement (such as competing in sports) result in the desired reorganisation of the neurological systems?

The rather gloomy news is that skills from lower levels are very much needed as they build on each other and take on a foundational function. A 'gap' in the foundation can therefore compromise the entire learning structure. The child may struggle with expected age appropriate physical skills and the conduction of messages in the brain and the NS will usually be inefficient and slow, making academic learning more difficult. As a result many children might find it challenging to keep up with their peers and they may therefore not achieve to the level of their natural capacity. Learning becomes

difficult and stressful and seemingly simple tasks cause tiredness and distress (Kokot, 2010a:26; Move to Learn, 2012b). The good news is that these developmental stages can be addressed at any age. If a child is having difficulty at school, sometimes simply guiding them through these developmental milestones again (or perhaps for the first time) can help them fill in the missing gaps and become ready for academic learning. Simple and unsophisticated movement programmes are used for exactly this purpose (Move to Learn, 2012b). For instance, a reflex stimulation/inhibition programme may improve cerebellar functioning by maturing the postural reflex system (Goddard, 2005:47), and act to prevent barriers to learning (Kokot, 2010a:86). Movement programmes are designed to help children acquire the skills they need in the natural way and order that they were originally intended to be acquired – through movement. Programmes require little in terms of training, space or equipment and take only a few minutes daily, most days of the week. The activities can be done with an individual, a small group or with a whole class, and statistically significant results have been seen to occur within two to three months (Fredericks *et al*., 2006; Krog, 2010: 93; Move to Learn, 2012b; Van der Westhuizen, 2007:332).

All learning requires movement, but not all movement guarantees learning. There is a difference between regular physical movements as opposed to sensory and perceptual motor programmes. It is only in the case of the latter that a significant difference is seen in academic performance and related social skills (Fredericks *et al*., 2006). Kokot (2007a:88) explains that having good gross motor skills does not necessarily mean that higher skills, which are normally built on gross motor skills, will develop. The aim of a sensory-motor or neurodevelopmental movement programme is to use specific movements to structure the brain, rather than conditioning the brain to enable the body to make certain skilled movements in order to play various sports. As such, the developmental movements in this study were specifically selected to stimulate neurological systems.

4.4 CONCLUSION

This chapter firstly provided an overview on several perceptual and sensory-motor concepts important for the understanding of the neurodevelopmental basis of human movement. Discussions on the vital sensory systems involved in developing learning through movement followed, with a focus on four of the five senses, namely the vestibular, the proprioceptive, the visual and the tactile senses.

The literature review in this chapter showed that:

- ***Vestibular impairment*** is common in children with sensorineural profound hearing loss, nonsyndromal and syndromal hearing impairment, as well as in children with congenital deafness (Kaga, Shinjo, Jin & Takegoshi, 2008; Nandi & Luxon, 2008; Wiener-Vacher, 2008).
- A dysfunctional vestibular system can in turn negatively affect the ***visual system*** (Cheatum & Hammond, 2000:266; Goddard, 2005:73; Goddard Blythe, 2000; Kokot, 2010b), as can a faulty auditory system (Erden, Otman & Tunay, 2004).
- Children with hearing impairment are furthermore at risk of having problems with ***ocular motility*** (Bist, Adhikari & Sharma, 2010). This could be explained by both a faulty vestibular system, as well as the child with hearing impairment's higher probability of aberrant ***ATNR and STNR reflexes*** exist (Rosen & Joffee, 1995:501). Both these aberrant reflexes have an adverse effect upon ***eye tracking***.
- Difficulties with ***convergence,*** as a critical aspect of binocular vision, can possibly be explained by an ***aberrant TLR*** (Goddard, 2005:73).

Most importantly, difficulties with any of the above-mentioned sensory-motor and reflex subsystems can negatively influence the overall development of the child with hearing loss.

The chapter concluded with an overview on the interrelatedness of the sensory systems and a brief discussion on the importance of movement in the process of learning. Sensory-motor integration programmes assist children to replicate the early movement experiences that are required to establish good building blocks, or wiring of the brain

that is essential for efficient learning. This approach is based on the principle that children with learning difficulties have developmental immaturities, including poor neurological organisation. By replicating early movement patterns, children are helped to gain the sensory-motor processes that they may lack.

Chapter five presents the empirical intervention design.

CHAPTER FIVE

RESEARCH METHODOLOGY: THE EMPIRICAL INVESTIGATION

"It is a habit of questioning what you do, and a systematic examination of the observed information to find answers, with a view to instituting appropriate changes for a more effective professional service."

(Kumar, 2005:2)

5.1 INTRODUCTION AND CHAPTER PREVIEW

Research involves a systematic process of collecting and logically analysing and interpreting information (data) to answer questions. There are various methods and approaches of investigating a problem or a research question. Research is not limited to one approach (Kumar, 2005:7-8). Goodwin (2010:3-4) acknowledges that research involves the application of various methods and techniques in order for the researcher to arrive at conclusions and to create scientifically obtained knowledge by using objective methods and procedures. During the course of completing this research study, the researcher became aware that a thorough knowledge of research methods makes one a more informed and critical consumer of information.

In the previous chapters a literature review was done to explore the constructs related to neurodevelopment, the auditory system in particular and the role movement plays in the maturation of neurological systems. As these chapters indicated, appropriate movement is crucial to general neurodevelopment and a lack of appropriate movement (as seen in the presence of aberrant primitive reflexes) has been associated with delays in development. It was said that movement structures the brain, and is thus responsible for maturation of the brain. Special reference was made to the child with hearing impairment throughout the literature review, concluding that this sensory deficit can have a general negative effect on the child with hearing impairment's overall functioning.

Enhancing readiness to learn through suitable intervention and stimulation can go a long way towards improving the capacity of children with hearing impairment to learn and ultimately to become skilled. This becomes even more important in previously disadvantaged communities where children with disabilities have rarely had the opportunity to experience educational intervention in preparation for formal schooling. In this context, the purpose of this chapter is to present the research methodology that was used in the collection of the data for this study. This chapter elaborates on the methodological constructs introduced in chapter one.

The implementation of the intervention programme on a sample of four to eight year-old children with hearing impairment is discussed in this chapter. The motivation for the study, goals of the research and the method are outlined. A description of the research design, participant selection, measuring instruments, intervention programme and the procedure followed concludes this chapter.

5.2 RESEARCH GOAL AND HYPOTHESES

As indicated in chapter one, the research ***goal*** for this study was:

To implement, evaluate, and design guidelines for a neurodevelopmental movement programme for 4 to 8 year-old children with hearing impairment in a rural South African community.

The research problem is encapsulated in the research ***objectives,*** which are as follows:

- To provide a theoretical foundation for the implementation of a neurodevelopmental movement programme for the sample of children with hearing impairment through a literature review about the child with hearing impairment, especially in a rural community; neurodevelopmental systems involved in overall development and neurodevelopmental movement interventions.
- To implement developmental movements and activities (a neurodevelopmental movement programme) in order to stimulate the integration of primary reflexes and the optimal functioning of sensory-motor systems that support human functioning for

a period of 14 weeks to a sample with hearing impairment experimental group.

- To ascertain if there are statistically significant differences between the pre-intervention and the post-intervention test scores on the:
  - Griffiths Mental Development Scales – Extended Revised (GMDS-ER)
  - Child Behaviour Checklist (CBCL)
  - Neurodevelopmental Evaluation Scale (NES)
- To report the results of tests in the form of a neurodevelopmental profile for the specific sample by reviewing the results on the developmental subscales of the GMDS-ER and the activities of the NES
- To describe the results comprehensively in order to propose guidelines and make recommendations for research and practice.

The following ***hypotheses*** were formulated as directive questions to the research and are applicable to the pre- and post-intervention testing:

Hypothesis 1:

H0: The movement programme does not improve the experimental group's **development** significantly.

H1: The movement programme does improve the experimental group's **development** significantly.

Hypothesis 2:

H0: The movement programme does not change the experimental group's **behaviour** significantly.

H1: The movement programme does change the experimental group's **behaviour** significantly.

Hypothesis 3:

H0: The movement programme does not change the experimental group's **performance on the neurodevelopmental evaluation** scale significantly.

H1: The movement programme does change the experimental group's **performance on**

the neurodevelopmental evaluation scale significantly.

In an attempt to respond to the above hypotheses, a systematic approach to the research was followed. Clark-Carter (2010:3) refers to this as the research method. The following section expands on the research method and design of the study.

5.3 RESEARCH METHOD AND DESIGN

This research follows a ***quantitative approach***, based on the collection of numerical data, in order to determine whether a movement programme can cause change (Mertens, 2010:3). The quantitative approach was described in chapter one. A quantitative approach was chosen to reduce the likelihood of subjective interpretation of findings. This is one of the features of quantitative methodologies (Gravetter & Wallnau, 2011:xiii, 89; McGee, 2010:86; Stangor, 2011:15, 108). The researcher attempts to provide a clear and objective representation of the goal or purpose of the study through the statistical analysis of numerical data.

The current study requires the measurement of behavioural outputs with the use of standardised assessment tools (GMDS-ER and CBCL), which conform to the criteria for delivering quantitative data. Other aspects incorporated in this study, such as the assessment of the functioning of the vestibular system, the visual system, and the reflex system were more difficult to measure quantitatively. However, a scale for this purpose (the Neurodevelopmental Evaluation Scale - NES) was specifically designed to provide a quantitative measure for the assessment of neurological subsystems (see Addendum C). The quantitative approach made it possible to determine the sample's level of functioning prior to the implementation of the movement programme as well as the impact of the movement programme on the sample's level of functioning according to the posttest results.

As indicated in chapter one, a ***quasi-experimental research design*** *(specifically the comparison group pretest-posttest design)* was selected to obtain data before and after the implementation of the movement programme. This was done to determine the

impact of the movement programme, and to answer the question of whether statistically significant differences exist between the pre-intervention and the post-intervention test scores.

5.3.1 The Comparison Group Pretest-Posttest

Pretest-posttest design is the most widely used between-group design in treatment-outcome research for the purpose of comparing groups and measuring change resulting from experimental treatments (Dimitrov & Rumrill, 2003). It is the equivalent of the classic experiment, but without random assignment of subjects to the groups (Fouché & De Vos, 2005b:140). This design was chosen to evaluate the effect of the intervention programme on children with a hearing impairment.

Dimitrov and Rumrill (2003) state that this design has practical advantages over randomised group designs, because it deals with intact groups and as a result does not interrupt the existing research setting. This reduces the reactive effects of the experimental procedure, and therefore improves the ***external validity*** of the design. A nonrandomised design is, however, more sensitive to ***internal validity*** problems so that even where there are posttest differences between the groups, those differences may be attributable to characteristic differences between the groups rather than to the intervention (Dimitrov & Rumrill, 2003; Manuel *et al*., 2011:156).

Clark-Carter (2010:42) and Dimitrov and Rumrill (2003) define internal validity as the degree to which the experimental treatment makes a difference – in other words, that the experiment successfully demonstrates that changes in a dependent variable are caused by changes in an independent variable. External validity is the extent to which findings in one study can be applied to another situation and are therefore generalisable to other settings (Clark-Carter, 2010:27; Dimitrov & Rumrill, 2003; Grinnell, Unrau & Williams, 2011:269; Mertens, 2010:129). Each time the findings from one study are also observed in another situation, the results are said to be generalisable or externally valid.

A major disadvantage of nonrandom allocation of participants to groups is that the

experimental and comparison groups may not be equal. Random assignment to groups within the quasi-experimental design, on the other hand, equalises groups on existing characteristics, and, thereby isolates the effects of the intervention (Dimitrov & Rumrill, 2003). Clark-Carter (2010:46) agrees, and sets two requirements for improving internal validity, namely: 1) the existence of a comparison group which does not receive any treatment; and 2) the randomisation of participants to the experimental and comparison groups.

The comparison group pretest-posttest design consists of two groups. One group receives the intervention and the other does not. The groups are tested before and after the intervention. The effect of the intervention is reflected in the scores from pre- to post-assessment (Fouché & De Vos, 2005b:140).

The design can be diagrammed as follows:

Experimental group:	O_1	X	O_2
Comparison group:	O_1		O_2

O stands for an observation or assessment of behaviour, *X* for the experimental manipulation or treatment or independent variable. The subscripts 1 and 2 refer to the sequential order of recording observations or assessments, with the *O1* representing pretests and the *O2* referring to posttests (Fouché & De Vos, 2005b:134; Rubin & Babbie, 2008:251).

The pretest gives an indication of the status of the groups before the intervention. The use of the pretest affords a statistical advantage in providing a baseline for the data analysis. The posttest indicates whether change took place as a result of the intervention, not only with regard to groups but also with regard to individuals (Rossi, 2005:73). For the purposes of this study, possible improvement in abilities was measured by comparing the differences between pre- and posttest scores on the subscales of the Griffiths Mental Development Scales – Extended Revised (GMDS-ER), the Child Behaviour Checklist (CBCL) and a neurodevelopmental evaluation scale

(NES). These measures are discussed later in this chapter. For ethical reasons the intervention was offered after post-testing to the children who did not receive the treatment during the experiment.

5.3.2 Selection of the Sample

As explained in ***chapter one***, nonprobability purposive sampling was used to obtain the sample of children with a hearing impairment in a rural area of South Africa. Random allocation could therefore not be used. One school was selected on the grounds that the school was situated in a rural area in the Free State Province of South Africa, and that the school offered special services for children presenting with a hearing impairment.

The sample group came from three classrooms, which included Grades Pre-R, R, and One. A total of 20 children were initially included in the research. The children were between the ages of 4.5 and 8 years. Two of the twenty children were not selected due to suspected intellectual handicap, as their scores during the pretesting phase on the GMDS-ER were very low in comparison with the rest of the group. To prevent the two children from feeling excluded they were included during the activities done with the two groups. No children were suspected of having cerebral palsy or autism. The total number of children included in the research was therefore 18 (N = 18). To conform to the requirements proposed by Clark-Carter (2010:46), the participants in the three classes were divided into two equal groups (n = 9) on a random basis, provided that the two groups were fairly equal in terms of age, gender, level of hearing loss, parental employment status and basic developmental ability. Group homogeneity was strived for as much as possible. Macnee and McCabe (2008:129) note that studies using a nonprobability purposive sample may encounter some bias, which may influence the results. This is because all nonprobability samples have the potential that some outside unidentified factor directs who is included or not in the study. However, because this bias is evenly distributed among the two groups, the bias will not unduly affect the outcomes of the study. The characteristics of the sample are discussed in more detail in chapter 6.

Children in Group 1 (the experimental group) took part in the neurodevelopmental movement programme and children in Group 2 (the comparison group) only received the neurodevelopmental movement programme after completion of the experiment. The children in the comparison group took part in other activities, such as painting, building puzzles, storytelling, colouring in, throwing balls, walking over beams and playing on jungle gyms.

5.3.3 The Validity of the Research

Clark-Carter (2010:40-42) notes that the fundamental aim of a research study is usually to establish a link between one or more independent variables and dependent variables or to generalise the results found with the participants used in the study with other groups of people. As mentioned, these constructs are referred to as internal validity and external validity respectively. Both internal validity and external validity are achieved in a research design by taking into account several threats that are inherent to all research efforts (Grinnell *et al.*, 2011:265). Although it is virtually impossible to meet all standards of validity in research, the key issue is that reasonable efforts were taken to avoid or minimise those problems (Rubin & Babbie, 2008:267). This subsection focuses on threats to validity relevant to this study.

5.3.3.1 External Validity

Threats to external validity relevant to this study include aspects of the participants and pretest treatment interaction (Clark-Carter, 2010:41; Grinnell *et al.*, 2011:269).

The researcher may wish to generalise from the sample used in the study (18 children with hearing impairment at a special school in QwaQwa between the ages of four and eight years) to the population (all children with hearing loss in QwaQwa between the ages of four and eight years) or even the universe (all four to eight year-old children with hearing loss in rural South Africa) from which these ***participants*** were drawn. The reality is that unless the sample is a fair representation of the group from which they were selected, there are limitations on generalising any findings to the wider group (Clark-Carter, 2010:41). Although two standardised testing measurements were used

and a structured programme of intervention was followed in this study, contributing to the generality of constructs and uniformity of the outcome measures, these remain threats to external validity of a study (Rossi, 2005:74). The researcher's aim was not to generalise the findings of this study, but rather to ascertain if statistically significant differences exist between the pre- and posttest assessments in this sample of children with hearing loss, where little is known about the effect of movement programmes on their general development. One of the core ways to improve external validity would have been to randomly select the participants from the wider group which they represent (Clark-Carter, 2010:42). However, a nonprobability sample was selected in this study because it takes advantage of respondents who are already available (Morgan, Gliner & Harmon 2005:125).

As ***pretesting*** is built into the design of this study, it may be viewed as a potential threat to the external validity as the nature of the pretesting can alter the way in which the participants respond to the experimental treatment, as well as to the posttest (Grinnell *et al*., 2011:269). In this study both the experimental and the comparison groups were pretested, thus avoiding the possibility of contaminating effects of pretesting in only one group.

5.3.3.2 Internal Validity

Threats to the internal validity of this study are relevant as this study makes use of a quasi-experimental research design. These threats include the selection of the participants, maturation, history, instrumentation, regression to the mean, attrition, imitation or diffusion, compensation, demoralisation, and novelty or disruption effects (Clark-Carter, 2010:40-43; Rubin & Babbie, 2008:267). Many of these threats to internal validity can be lessened by the use of a comparison group which does not receive the selected treatment (Clark-Carter, 2010:46), which was the case in this research study.

Selection bias is dependent on differences in groups after groups are selected. This may be relevant to this study as the two groups may not be completely homogeneous with regard to all possible variables (Clark-Carter, 2010:43). ***Maturation*** refers to

changes over time or processes within the participants which may have influenced results. ***History*** refers to any outside event occurring in the experiment or in the life of the participants that may account for the results in certain participants, and that was not taken into account in the research design (Clark-Carter, 2010:43; Grinnell *et al*., 2011:265). In this study, a comparison group is part of the design and all participants were selected on the grounds of their hearing impairment and social status to maximise homogeneity of groups. Participants were also allocated to the different groups on a random basis. In addition, all the participants resided fulltime on the school premises in hostels, which limited the influence of outside events in the lives of participants to a considerable degree.

Instrumentation refers to changes in the dependent measure in that ratings change or the participant's responses are influenced by the tester (Clark-Carter, 2010:43). The effect of this threat was restricted by the use of standardised tests. The researcher aimed to quantify one of the scales, the NES, to further restrict this threat to internal validity. ***Regression*** to the mean refers to assessment scores reverting to the mean when tests are re-administered (Clark-Carter, 2010:45). In this study, standardised tests were used by the researcher, who is a trained psychologist, to control for this effect. Neither were participants selected for either group based on their score on the pretesting phase of the study. ***Attrition or experimental mortality*** refers to the loss of subjects before the experiment is complete, which may affect the statistical comparisons and conclusions (Clark-Carter, 2010:44; Rubin & Babbie, 2008:268). This threat was obviated as the sample remained unchanged throughout the study and the overall statistics were therefore not weakened by attrition.

Imitation or diffusion occurs where comparison group participants learn from their experimental group peers. This may happen when participants from the experimental group and comparison group talk to each other about the study (Clark-Carter, 2010:44; Grinnell *et al.*, 2011:269; Rubin & Babbie, 2008:267). In this study, there was always the possibility that a participant in the experimental group would explain the movement activities to a friend who happened to be in the comparison group. The extent to which

imitation between the groups may have occurred is difficult to determine. This threat was restricted in this study as the researcher and occupational therapist interacted equally with the comparison group. This might have created the impression that the participants were doing the same activities, and so decreased the probability of them discussing the activities out of curiosity. In addition, the participants have a hearing deficit and so have limited communication abilities. The researcher did not notice participants from the groups teaching each other movement activities. The researcher furthermore did not demonstrate experimental group intervention activities when engaging with comparison group participants. Care was also taken to avoid comparison group participants walking in on the experimental group during times when they were doing the movement programme.

Compensation occurs when others interact with the participants in different ways based on the group they belong to. This can undermine the research in a way that improves the performance of one of the groups (Clark-Carter, 2010:45; Grinnell *et al.*, 2011:269; Rubin & Babbie, 2008:268). The researcher restricted this threat by ensuring that class teachers did not know which group the children in their classes belonged to. There was furthermore no need for compensation on the part of the researcher or the class teacher, as the ethical design of the study offered the comparison group the same intervention on completion of the study. Children in the two groups were therefore unlikely to have been treated differently during the course of the research.

Demoralisation occurs if the participants in one group feel that they are missing out. Their feelings of deprivation may cause them to decide to apply less effort than they would normally do. That may artificially lower the results of that group on outcome measures. It is further also possible that changes occur amongst experimental group participants simply because they sense that they are getting special attention or special treatment. These ***novelty or disruption effects*** can occur because introducing an innovation in a setting where little innovation has previously occurred can stimulate excitement and energy among recipients of the intervention. That would have the effect of artificially raising the results of that group on outcome measures (Clark-Carter,

2010:45; Grinnell *et al.*, 2011:269; Rubin & Babbie, 2008:266-268). The researcher was aware of the possible effects of demoralisation and novelty and wished to control for that. These threats to internal validity were restricted in that the participants in the comparison group participated equally in activities facilitated by the researcher and the occupational therapist. The only difference was that the activities did not form part of the specific movement activities found in the neurodevelopmental movement programme, although they still allowed for children to interact with the researcher and the occupational therapist to the same extent as the experimental group. Rubin and Babbie (2008:267) refer to this as a placebo group design. Placebo group participants receive special attention of some sort, although different from the intervention received by the experimental group. The diagram of the comparison group pretest-posttest design presented earlier in this chapter can therefore be adapted to more specifically illustrate the general research design used in this study (see figure 5.1).

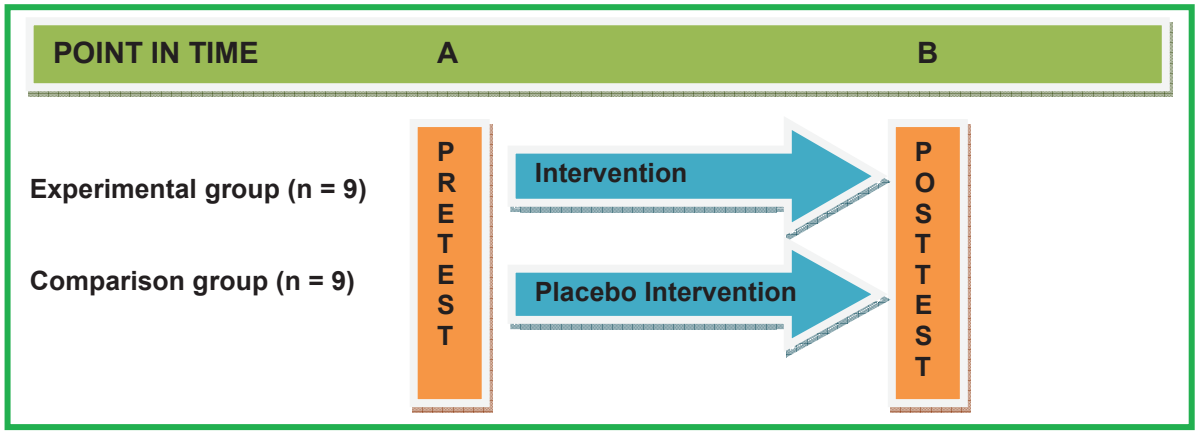

Figure 5.1 Research Design

This section outlined the research design against the backdrop of quantitative research, the comparison group pretest-posttest design, the selection of the participants for the study, and internal and external validity. The measuring instruments used during the empirical investigation are dealt with in the next section.

5.4 MEASURING INSTRUMENTS USED IN THE EMPIRICAL INVESTIGATION

The concepts of time and maturation are important in child development, as they provide insight into a child's development and allow for the identification of neurodevelopmental

delay. Van der Westhuizen (2007:135) states that the time factor holds different positions in terms of ***chronological age*** and ***developmental age***. The former refers to the actual time lapsed since the birth of the child. The latter refers to the age according to set stages of development. The ability to determine developmental age stems from knowledge of the specificity of developmental stages, and the knowledge of when this should take place. The discrepancy between chronological age and developmental age maps the developmental delay. Goddard (2005:130) notes that although the symptoms of the developmental delay may be similar for many children, the developmental route that children have taken to compensate for their problems is as individual as the children themselves. This is why Goddard (2005:130) advocates using a battery of tests when assessing the child. She recommends several key areas for investigation, including balance, gross and fine muscle coordination, reflexes, oculo-motor functioning, visual-perceptual performance, and performance on specific age-related tasks.

For the purposes of this study, developmental assessment is considered to include a comprehensive psychological investigation of the child with hearing impairment's abilities. This includes the assessment of motor, social, behaviour and cognitive (including language, memory, reasoning and problem-solving) abilities, as well as sensory-motor functioning. Quantitative measuring instruments were included in the pre- and post-assessment stages of the movement programme to investigate the child with hearing impairment's abilities. In terms of the hypotheses formulated for this study, the development, the behaviour, and the functioning of the sensory-motor systems of the participants had to be assessed and measured. An outline of the measuring instruments used at various stages in the research is presented in table 5.1.

Table 5.1 Measurement Instruments

Measurement Instruments	Pretesting assessment	Posttesting assessment
Biographical Questionnaire Completed by the parent/s and verified by the researcher	☑	
Griffiths Mental Development Scales – Extended Revised (GMDS-ER) Administered by the researcher	☑	☑
Child Behaviour Checklist (CBCL) Completed by the class teachers	☑	☑
Neurodevelopmental Evaluation Scale (NES) Administered by the researcher	☑	☑

A discussion on the selected measuring instruments follows.

5.4.1 Biographical Questionnaire

The researcher compiled a 20-item biographical questionnaire (see Addendum B) to gather demographic and background information. This questionnaire was administered to the participants' parents after obtaining written consent from them for the participation of their children in the study. Questions related to the child's gender, cultural group, socioeconomic status, age, home language, age of enrolment at the school, medical history, as well as the nature of the child's hearing deficit and the existence of additional comorbid conditions. The biographical information collected via the biographical questionnaire was then collated with the information in the children's school files.

5.4.2 Griffiths Mental Development Scales – Extended Revised (GMDS-ER)

South Africa consists of various cultural groups and by virtue of the country's political history, measurement instruments have seldom been developed or standardised for all cultural groups. Results may thus be biased, which and can have implications for the individual involved. Since the first democratic elections, held in 1994, the country has had a new constitution and there are stronger demands for culturally appropriate

psychological tests (Meiring, Van de Vijver, Rothman & Barrick, 2005).

The Griffiths Mental Development Scales – Extended Revised (GMDS-ER) (Luiz, Faragher, Barnard, Knoesen, Kotras, Burns & Challis, 2006; Luiz, Barnard, Knoesen, Kotras, McAlinden & O'Connell, 2004) is one of the few developmental measures that can be used with confidence in a multicultural country such as South Africa (Schröder, 2004.62). The Griffiths Scales is one of the most widely used and researched measures for assessing both general and specific aspects of childhood development (Luiz, Foxcroft & Povey, 2006b). It was introduced to South Africa in 1977 (Amod, Cockcroft & Soellaart, 2007).

A major internationally re-standardised version of the GMDS-ER was published in May 2006, with British Isles statistical analyses (Luiz, Faragher *et al*., 2006:9). A number of item changes have been introduced. The administration manual, analysis manual and record books have been substantially improved. They provide easy-to-follow, unambiguous assessment guidance, simplified percentile and z-score ratings and concise recording formats which are ideal for consecutive assessments such as in chronic disorders or neonatal follow-up programmes (Association for Research in Infant and Child Development [ARICD], 2012). Although the GMDS-ER has been standardised on a group of British children aged two to eight years whose first language is English (Luiz *et al*., 2004:4), Schröder (2004:62) explains that possible cultural influences are neutralised to some extent. This is because the test was developed by observing children in their natural environments while walking, talking and playing and these activities are common to most, if not all, cultures. The GMDS-ER is widely used for both clinical and research purposes (ARICD, 2012).

After the first study on a population with hearing loss with the GMDS-ER was done in South Africa, Schröder (2004:70, 160) concluded that the GMDS-ER is a useful psychometric measure to evaluate the developmental profiles of children with hearing impairment in South Africa. There is furthermore ample support for the construct validity of the original Griffiths Scales of Mental Development within South Africa's multiracial

population (Schröder, 2004:89). ***Construct validity*** refers to the extent to which a measured variable actually measures the construct that it is designed to measure (Stangor, 2011:95). Luiz, Foxcroft and Stewart (2001) contributed to our knowledge of the construct validity of the Griffiths Scales by demonstrating a correlation between a South African sample of 430 children (from white, mixed race, Asian and black ethnic groups) and British subjects. This suggests that the Griffiths Scales measure a construct which is consistent across cultures and through time. A factor analysis of the data for each South African ethnic group indicated that the Griffiths Scales consistently measure one factor, which is crossculturally similar. The GMDS-ER is consequently recognised as a core measure in the assessment of South African children of all cultural and socioeconomic groups (Schröder, 2004:104).

During the standardisation of the GMDS-ER, the statistical analysis indicated that the items in the six subscales are representative of their respective content domains and that each item has a satisfactory degree of relevance to the construct being measured (Luiz, Faragher *et al*., 2006:25). On the GMDS-ER, Cronbach's alpha coefficients were independently calculated for each subscale as well as for the General Quotient (GQ) as an indication of the ***reliability*** of the subscales as a measure of mental development (Luiz, Faragher *et al*., 2006:23). Reliability of a measure refers to the extent to which it is free from random error. If the results on a measure are not consistent over time it will not be useful in research (Stangor, 2011:91). It was found that the overall reliability of the GMDS-ER is 0.993, which is highly satisfactory. On the whole, the reliability of the individual subscales ranges between 0.90 and 0.99, and is thus indicative of a high level of internal consistency (Luiz, Faragher *et al*., 2006:23). This indicates that the item scores on a scale correlate highly with each other (Stangor, 2011:91).

Although the majority of the initial research on the Griffiths scales took place in Great Britain, extensive international research has been conducted in Canada, China, France, Germany, as well as in South Africa and Australia. The results show that the GMDS-ER is applicable to children from different cultural groups in a variety of populations (Luiz *et al*., 2004:3). This research shows that this tool has practical and diverse applications in

the evaluation and treatment of infants and young children from a variety of cultural backgrounds (Cobos, Rodrigues & De Venegas, 1971; Collins, Jupp, Maberly, Morris & Eastman, 1987; Luiz, Foxcroft, Worsfold, Kotras & Kotras, 2001; Ramsay & Fitzharding, 1977; Sletten, 1970).

Table 5.2 illustrates the six subscales of the GMDS-ER, with a description of each subscale, as well as a condensed list of examples of items included in the subscale.

Table 5.2 Six Subscales of the GMDS-ER

(Luiz *et al.,* 2004:5-6)

Subscale	Description of the Subscale	Examples of Items included
Locomotor Subscale A	Assesses the child's gross motor skills, including ability to balance, and coordinate and control movements.	Age appropriate activities such as: • Walking up and down stairs • Kicking a ball • Riding a bike • Jumping • Skipping
Personal-Social Subscale B	Assesses the child's proficiency in the activities of daily living, level of independence and ability to interact with other children.	Age appropriate items such as: • Dressing and undressing • Competency in using cutlery • Knowledge of information such as his date of birth or address
Language Subscale C	Assesses the child's receptive and expressive language.	Age appropriate items such as: • Naming objects and colours • Repeating sentences • Describing a picture • Answering a series of questions about comprehension / similarities / differences.
Eye-and-hand Coordination Subscale D	Assesses the child's fine motor skills, manual dexterity and visual perceptual skills.	Age appropriate items such as: • Threading beads • Cutting with scissors • Copying shapes • Writing letters and numbers

Performance Subscale E	Assesses the child's manipulation skills including speed of working and precision.	Age appropriate activities such as: • Building bridges and stairs • Completion of formboards • Pattern making
Practical Reasoning Subscale F	Assess the child's ability to solve practical problems, understanding of basic mathematical concepts and questions about moral and sequential issues.	Age appropriate activities such as: • Counting • Comparison of size, length and height • Knowledge of days of the week • Ability to tell the time • Understanding of right and wrong

The administration and scoring of the GMDS-ER is outlined in the next subsection.

5.4.2.1 Administration and Scoring of the GMDS-ER

In this study the GMDS-ER assessments were administered in the pretest and the posttest phase by the researcher, who completed an accredited training course by ARICD (Association for Research in Infant and Child Development) in the administration of the scales in 2003. Administration and scoring were followed according to the administration manual (Luiz *et al*., 2004:12) and the analysis manual (Luiz, Faragher, *et al*., 2006:20). Clinical use of the Scales is restricted to psychologists and developmental paediatricians who have completed accredited training courses by the Association for Research in Infant and Child Development (ARICD, 2012).

Each child was evaluated individually in a large room at the school's clinic. Care was taken to choose a room without windows to avoid external distractions as far as possible. The clinic's sign language interpreter was included in the testing process and assisted the researcher during both the pre- and posttest assessments. As the sign language interpreter also lives on the school premises and in the hostel for the hearing impaired, she was also asked to answer self-report questions as part of the GMDS-ER, which collected information on the child's personal-social functioning.

The time to administer the GMDS-ER varies according to several factors. These include

the skill of the researcher, the ability to move competently and efficiently between the subscales to determine a basal and a ceiling for each scale, as well as the child's concentration and ability. Luiz *et al*. (2004:16) gives a guide of between 60 and 90 minutes. An assessment took approximately 80 minutes, and was completed in a single session. All children were assessed across all six subscales.

The researcher was responsible for scoring the test. A record sheet is used to record all items passed or failed. Items are graded developmentally across all subscales. After six consecutive items failed in a subscale, testing is terminated on that subscale as the child's level on that particular subscale has been reached. All items passed were used to determine an equivalent age level (also referred to as 'mental age' or 'developmental age') in months (Luiz, Faragher *et al.,* 2006:21; Luiz *et al.*, 2004:21). Age equivalent levels in months were calculated for each of the six subscales, as well as for the total scale using the normative tables in the GMDS-ER analysis manual (Luiz, , Faragher *et al*., 2006:52-261). The raw sub-quotients and the general quotient were not required for this study. In cases where a child's subscale raw score were below the point that could be converted to an equivalent age level using the normative tables in the GMDS-ER analysis manual, they were calculated as achieving a developmental age of 24 months. In cases where a child's subscale raw score were above the point of being converted to an equivalent age level using the normative tables, they were calculated as achieving a developmental age of 96 months (Luiz, Faragher *et al*., 2006:52-261).

5.4.3 The Child Behaviour Checklist (CBCL)

In recent years, researchers have investigated the mental health functioning of children and adolescents with deafness using three companion instruments developed by Achenbach (Achenbach System of Empirically Based Assessment [ASEBA], 2012; Wallis, Musselman & MacKay, 2004). The Child Behaviour Checklist (CBCL), the Teacher Report Format (TRF), and the Youth Self Report (YSR) are widely used and well-standardised tools for measuring child and adolescent psychopathology in the general population (Wallis *et al*., 2004). The CBCL, TRF, and YSR are components of ASEBA (the Achenbach System of Empirically-Based Assessment) (Achenbach &

Rescorla, 2001:16; ASEBA, 2012). These instruments enable professionals from many backgrounds to quickly and effectively assess diverse aspects of adaptive and maladaptive functioning and obtain standardised ratings of diverse aspects of behaviour, emotional, and social functioning (Achenbach & Rescorla, 2000:1; Achenbach & Rescorla, 2001:iv). It was found that the overall ***test-retest reliability*** across all the scales of the three instruments was high for most scales (Achenbach & Rescorla, 2000:75, 100; Achenbach & Rescorla, 2001:102, 109, 135). Test-retest reliability refers to the extent to which scores on the same measured variable correlate with each other on two different measurements given at two different times (Stangor, 2011:91). There is furthermore strong support for the content validity, criterion-related validity, and construct validity of the test items (Achenbach & Rescorla, 2000:75, 100; Achenbach & Rescorla, 2001:102, 109, 135).

The CBCL has been used in diverse populations in South Africa (Sotho and Sepedi), as well as with disability groups and in rural communities; and has been found to be a reliable measure (Achenbach, 1991:7). The CBCL has been used in South African studies with samples of children who recovered from tuberculous meningitis (TBM) (Wait & Schoeman, 2010), to test the association between low birth weight and psychological symptoms in a sample of children in Soweto (Sabet, Richter, Ramchandani, Stein, Quigley & Norris, 2009), to assess children whose parents had full-blown AIDS (Acquired Immune Deficiency Syndrome) (Gwandure, 2007), and to investigate the prevalence of attention deficit hyperactivity disorder (ADHD) in children recovered from TBM (Wait, Stanton & Schoeman, 2002).

Both the Child Behaviour Checklist for Ages six to eighteen (CBCL/6-18) – Teacher Report Form (TRF) and the Child Behaviour Checklist for Ages one-and-half to five (CBCL/1½ -5) – Caregiver-Teacher Report Form (C-TRF) are completed by teachers and other school personnel who have known a child in a school setting for at least two months and who are familiar with the child's functioning. The TRF and C-TRF provide an efficient and economical way to quickly obtain a picture of the child's functioning in school, as seen by teachers (Achenbach & Rescorla, 2000:iii; Achenbach & Rescorla,

2001:iii, 11).

The *CBCL/6-18 (TRF)* consists of over 100 items, and the *CBCL/1½-5 (C-TRF)* consists of 100 items that the teacher is asked to rate on a three-point scale *(not true, sometimes or somewhat true, very or often true)* for the item's applicability to the child (Achenbach & Rescorla, 2000:7; Achenbach & Rescorla, 2001:14-15). The *CBCL/6-18 (TRF)* includes eight constructs or syndrome scales, with the Attention Problem syndrome scale being divided into two subscales (Inattention and Hyperactivity-Impulsivity) (see table 5.3).

Table 5.3 Syndrome Scales of the *CBCL/6-18 (TRF)*

(Achenbach & Rescorla, 2001:22 – 23, 88)

Syndrome Scales	Examples of Items
Anxious / Depressed	• Cries a lot • Fears • Fears of school • Fears doing badly • Must be perfect • Hurt when criticised • Afraid to make mistakes
Withdrawn / Depressed	• Enjoys few activities • Would rather be alone • Refuses to talk • Lacks energy
Somatic Complaints	• Feels dizzy • Overtired • Aches, pains • Headaches • Vomits frequently
Social Problems	• Too dependent • Lonely • Doesn't get along with others • Jealous • Gets teased

Thought Problems	• Harms self • Twitching • Picks skin • Repeats acts • Stores things • Strange behaviour
Attention Problems **Subscales:** ***(Inattention & Hyperactivity-Impulsivity)***	• Acts young for age • Fails to finish tasks • Can't concentrate • Confused • Can't sit still • Fidgets • Disturbs others
Rule-breaking Behaviour	• Lacks guilt • Breaks rules • Bad friends • Lies, cheats • Steals
Aggressive Behaviour	• Argues a lot • Mean to others • Defiant • Destroys own things • Disobedient in school • Gets into fights

In addition to focusing on a child's behaviour as defined by the eight syndrome scales, the *CBCL/6-18 (TRF)* also allows the examination of two broad groupings of syndromes, namely T-scores for Internalising Problems (INT) and Externalising Problems (EXT). The instrument also generates a Total Problems Score (TS). The INT scale is made up of the Anxious/Depressed, Withdrawn/Depressed and Somatic Complaints subscales. This grouping is called "Internalising" because it comprises problems that are mainly within the self. The EXT scale is made up of the Rule-breaking Behaviour and Aggressive Behaviour subscales. The second grouping is called "Externalising" because it comprises problems that mainly involve conflicts with other people and with their expectations for the child. The TS is made up of the INT and the EXT scale, as well as the additional Social Problems, Thought Problems, Attention Problems and

Other Problems subscales that do not form part of the syndromes (Achenbach & Rescorla, 2001:24-25).

Based on T-scores, the child is placed in the “clinical range”, “borderline range”, or “normal range”. In general, T-scores of 60 to 63 are considered borderline, while higher scores are considered of clinical severity and indicative of significant internalising (emotional) or externalising (behavioural) problems. T-scores of 65 to 69 on the syndrome scales are considered borderline and high enough to be of concern, but not so high to be as clearly deviant as those in the clinical range (T-scores above 70). T-scores above 70 thus indicate that reported problems are a clinical concern (Achenbach & Rescorla, 2001:24, 90; Wallis, *et al.*, 2004).

The *CBCL/1½-5 (C-TRF)* includes six constructs or syndrome scales (see table 5.4).

Table 5.4 Syndrome Scales of the *CBCL/1½ - 5 (C-TRF)*

(Achenbach & Rescorla, 2000:16, 151-152)

Syndrome Scales	Examples of Items
Emotionally Reactive	• Disturbed by change • Twitches • Sudden mood changes • Sulks a lot • Upset by new people / situations
Anxious / Depressed	• Clingy • Feelings easily hurt • Upset when separated • Nervous
Somatic Complaints	• Aches, pains • Can’t stand things out of place • Headaches • Stomach aches • Vomits frequently

Withdrawn	• Acts young for age • Avoids eye contact • Doesn't answer questions • Refuses active games • Little interest
Attention Problems	• Can't concentrate • Can't sit still • Difficulty following directions • Fidgets • Clumsy
Aggressive Behaviour	• Can't stand waiting • Cruel to animals • Defiant • Destroys own things • Destroys others' things • Lacks guilt

Just as is the case with the *CBCL/6-18 (TRF)*, the *CBCL/1 ½- 5 (C-TRF)* also allows the examination of two broad groupings of the six syndromes in table 5.4. The grouping, designated as Internalising (INT), consists of the four syndromes (Emotionally Reactive, Anxious/Depressed, Somatic Complaints and Withdrawn). Again, this grouping comprises problems that are mainly within the self. The Externalised (EXT) grouping consists of two syndromes (Attention Problems and Aggressive Behaviour) and comprises problems that mainly involve conflicts with other people and with their expectations for the child (Achenbach & Rescorla, 2000:13). The instrument also generates a Total Problems Score (TS). The TS is made up of the INT and the EXT scale, as well as the other Problems subscale that are not on any of the syndromes (Achenbach & Rescorla, 2000:14).

The scoring of the CBCL/1 ½ - 5 (C-TRF) resembles that of the CBCL/6-18 (TRF) and the T-scores are interpreted in the same way for both sets of questionnaires (Achenbach & Rescorla, 2000:14, 16).

5.4.3.1 Administration and Scoring of the CBCL/6-18 (TRF) and CBCL/1½ -5 (C-TRF)

In this study the *CBCL/6-18* (TRF) (Achenbach & Rescorla, 2001) and the *CBCL/1½ - 5* (C-TRF) (Achenbach & Rescorla, 2000) were administered during the pre- and posttest assessments. The class teachers provided the information to complete these checklists for each child, and answers to the questions were factual and objective, rather than probing or interpretive. As the children in this sample were in a special setting for children with disabilities, the teachers were told to base their ratings on expectations for typical peers of the child's age, namely, children who do not have disabilities. This was necessary to provide appropriate comparisons with the norms of the ASEBA scales (Achenbach & Rescorla, 2001:iii).

The forms typically took approximately 15 to 20 minutes per child to complete. None of the teachers had difficulty completing the forms. Seventeen of the children in the sample were assessed on the *CBCL/6-18 (TRF)*. Achenbach and Rescorla (2001:6) state that this version of the CBCL may be used for 5 year-olds if they are likely to be reassessed with the same version again after their sixth birthday. Only one of the children was assessed on the CBCL/1½ - 5 (C-TRF) as she turned five during the course of the study.

The rationale for using the TRF and the C-TRF of the CBCL is that the children's parents rarely have contact with their children during a school term and may have not been able to provide information on the statements of the CBCL. Parent surrogates or teachers are among the most important sources of information about children's social and academic competencies, as well as about their behavioural and emotional problems (Achenbach & Rescorla, 2001:17, 56-71).

The researcher scored the teacher-rated checklists. The necessary T-scores were calculated by using the appropriate profile templates (Achenbach & Rescorla, 2001:208). For the purposes of this study the T-scores for the following syndrome scales were used: Anxious/Depressed, Withdrawn, Somatic Complaints, Attention Problems and Aggressive Behaviour. The T-scores for the INT, EXT and TS were also

used.

5.4.4 The Neurodevelopmental Evaluation Scale (NES)

Chapter four discussed the importance of the sensory-motor subsystems and their role in the overall development and learning readiness of a child. A typical screening consists mostly of clinical observations, but as this study follows a quantitative approach, care was taken to quantify these observations. The researcher assessed a variety of neurological aspects by compiling a 10-item scale (The Neurodevelopmental Evaluation Scale or NES) (see Addendum C for the NES and scoring protocol). It is important to recognise that these test items have also been used by other researchers (Cheatum & Hammond, 2000:71, 77, 155, 272, 277, 279; Kokot, 2005; Kokot, 2010a:45, 47, 56; Krog, 2010:77; Van der Westhuizen, 2007:313).

The NES did not include items for evaluating the proprioceptive system. This is because it is difficult to determine the exact location for a proprioceptive problem as it can lie anywhere along the child's entire sensory-motor process (Cheatum & Hammond, 2000:194). Several proprioceptive tests are available for evaluating movements of the body and body parts, coordinating the two sides of the body, and motor planning (Cheatum & Hammond, 2000:195). Due to the complexity of explaining (in sign language) what is expected of the child during some of the proprioceptive tests (such as the angels-in-the-snow test), and because the GMDS-ER has two subscales that assess the child's gross motor and fine motor functions, no proprioceptive test items were added to the NES. According to Cheatum and Hammond (2000:195), gross and fine motor evaluations tend to measure the proprioceptive system in younger children.

The NES did also not include any test items assessing the tactile system as most tactile system evaluations include blindfolding a child (such as the test for localisation of touch) (Cheatum & Hammond, 2000:231). As the participants were all either severely or profoundly hearing impaired, it was considered unethical to block the vital sense of sight, as this could cause the children to feel unsafe, also would negatively impact on the children's ability to understand what was expected of them. The children in the sample

had no other means of communicating, except for signing. No auditory system evaluation items were included in the NES.

The NES included test items for three primitive reflexes, namely the Asymmetrical Tonic Neck Reflex (ATNR), Symmetrical Tonic Neck Reflex (STNR) and the Tonic Labyrinthine Reflex (TLR). These three reflexes were selected because they are connected to the functioning of the vestibular system and associated pathways (Goddard Blythe, 2005; 2010).

The NES scoring system used for items testing aberrant reflexes was adopted from the Institute for Neuro-Physiological Psychology (INPP) (Goddard, 2005:86, 89, 90). The NES scoring system used for items testing balance and coordination (vestibular function) was adopted from a clinical gait and balance scale (GABS) (Thomas, Jankovic, Suteerawattananon, Wankadia, Caroline, Vuong & Protas, 2004). The remaining NES items were scored according to a scoring system developed by the researcher. The researcher chose a system related to the INPP and GABS systems to facilitate a level of scoring continuity. It must be noted that the items in the NES are not standardised for the South African context and interpretations should therefore be made with caution. However, NES items are described in sufficient detail to allow other researches to repeat these procedures. Myers and Hansen (2012:204) refer to this as giving the dependent variable a *measured operational definition*. This allows other researchers to replicate the procedures by following the same measure in the same way. The measurement procedures of the test items should be clearly and simply defined. The more accurate they are, the more likely they are to be reliable (Myers & Hansen, 2012:208).

The NES was conducted during the pre- and the posttesting phases and were administered after the GMDS-ER on the same day. The researcher administered the NES and received training in all of the test items from The Centre for Integrated Learning Therapy during a course on neurodevelopment in 2007 (Kokot, 2007b). All children took a short break of 30 minutes between the administration of the GMDS-ER and the NES. The NES took approximately 30 minutes to administer. The sign

language interpreter was available during both the pre- and posttest assessments to assist the researcher. A discussion of the NES items used to assess the neurological functioning of the vestibular, visual and reflex systems of the children in the sample follows.

5.4.4.1 The Vestibular System – Coordination and Balance

Tandem Walk

Tandem walking refers to heel-toe walking along a straight line. This test requires the child to walk with the heel of the one foot touching the toe of the other foot, without looking down at the feet. This test is conducted with the arms next to the child's sides and is done forwards and backwards with eyes open over a length of approximately five to six metres. The child should maintain balance. Normal five year-olds are usually successful and six year-olds should all manage this task (Bale, Bonkowsky, Filloux, Hedlund, Nielsen & Larsen, 2012:24; Kokot, 2007b:2; Larner, 2011:316). Goddard (2005:62) states that children with reflex problems can't locate their feet without looking at them. Struggling with this activity might also indicate poor proprioceptive awareness. Participants received a score of ***2*** if they were unable to complete the task, ***1*** if they managed with difficulty, and ***0*** if they could execute the task fully (Thomas *et al.,* 2004).

Manns Test

This test requires participants to stand on a straight line with the heel of one foot against the toe of the other foot and close their eyes. A six year-old child should be able to hold this position for about seven seconds. The test was done with the child's eyes open first. If children were unable to hold his or her balance with eyes open, the researcher took care when asking them to close their eyes as this would probably cause them to fall over (Cheatum & Hammond, 2000:154). This test is also referred to as a Tandem stance (Thomas *et al.,* 2004). Participants received a score of ***0*** if they could hold this stance for 20 seconds or longer, ***1*** if they managed between 10 and 20 seconds, ***2*** if they managed between 5 and 10 seconds, ***3*** if they could so for less than 5 seconds, and ***4*** if they were unable to do a single second (Thomas *et al.,* 2004).

Fog Walk

Here participants are required to walk on the outside soles of their feet. This is useful to determine whether there are movements in the face, hands and arms, which might be indicative of aberrant reflexes (Deuel & Rauchway, 2005:72; Kokot, 2007b:2). The researcher used a scoring system similar to that of the Tandem Walk. Participants scored ***2*** if they were unable to complete the task, ***1*** if they managed with difficulty and showed movement of upper extremities, and ***0*** if they executed the task well.

Cross Pointing Walk

The participants are instructed to walk forwards across the room, while they point at their feet. They should be pointing opposite hand to opposite foot and should not walk in a homolateral pattern. The researcher observes the ease with which the child crosses the midline and whether the movement is smooth (Kokot, 2007b:3). A scoring system similar to that of the Tandem Walk was used. The participants scored ***2*** if they were unable to complete the task, ***1*** if they managed but showed difficulties in crossing the midline, and ***0*** if they could do the task.

One Leg Test

Participants stand on their preferred foot, with the opposite leg bent at the knee and their eyes first opened and then closed. This is repeated using the non-preferred foot, with eyes open and then eyes closed. A six year-old should be able to hold this position for ten seconds (Cheatum & Hammond, 2000:154). Participants scored ***0*** if they could hold this stance for 20 seconds or longer, ***1*** if they managed between 10 – and 20 seconds, ***2*** if they managed between 5 and 10 seconds, ***3*** if they could so for less than 5 seconds, and ***4*** if they were entirely unable to do so (Thomas *et al.,* 2004).

5.4.4.2 The Visual System

Visual Tracking

Eye tracking skills are not fully developed until a child reaches the age of seven. Five year-olds can visually track an object, but their actions are not smooth or sustained (Cheatum & Hammond, 2000:278). During this test the child follows an object as it

moves through the full range of ocular movements (DeMyer, 2004:227). This assessment consisted of the researcher holding a pencil in front of the child's nose at eye level and moving it horizontally across his or her nose to the one side of the child's face, and then over to the other side. Participants must follow the pencil only with their eyes, without moving their head. The movement is made in a semicircular arc and avoid moving to a point where the opposite eye is blocked by the nose. The movement is repeated three times, before the track is smoothly changed to a diagonal direction, starting above the child's left eye and crossing the nose to below the right eye. This is repeated three times, after which the pencil then moves in a vertical direction from top to bottom and back three times. The activity then reverts to the diagonal pattern, starting above the child's right eye and crossing the nose to the below the child's left eye. Again this is repeated three times, before the tracking activity ends in three horizontal movements back and forth in front of the child's face (Cheatum & Hammond, 2000:279; Kokot, 2007b:6). The eye tracking assessment is first done with both eyes, then with the left eye only and then the right eye only. The researcher used a scoring system where participants scored ***12*** points if tracking was smooth in all directions, with no head movement, no jerky or watery eyes and maintaining focus. See Addendum C for the scoring system followed during this subtest.

Convergence, Accommodation and Divergence

Convergence and divergence are measured by holding the pencil in front of the child's nose and slowly moving it toward the tip of the nose and then returning to the starting position. Participants are instructed to follow the path of the pencil with their eyes. As the pencil moves closer, the eyes will slowly move toward the nose (converge), and diverge as the pencil moves back to its starting point. Accommodation is tested when the pencil stops in front of the nose (about five centimetres from the nose) and the child's eyes remain focused on the pencil without breaking and turning outward from the nose (Cheatum & Hammond, 2000:277). The researcher used a scoring system participants scored ***3*** points if their eyes managed to successfully converge, diverge and accommodate during this task. See Addendum C for the scoring system followed during this subtest.

5.4.4.3 The Reflex System

The assessment for possible retained (aberrant) reflexes probed for the presence of the asymmetrical tonic neck reflex (ATNR), the symmetrical tonic neck reflex (STNR), and the tonic labyrinthine reflex (TLR). The ***Schilder test*** was used to test for the ATNR, ***head tilts*** were used to test for the TLR, and the ***over and under*** method was used to test for the STNR (Goddard, 2005:86, 89, 90; Kokot, 2010a:44, 49, 57). The researcher adopted the INNP scoring system for evaluating these reflexes (Goddard, 2005:86, 89, 90; Goddard Blythe, 2010). The scoring of each reflex is given in Addendum C.

5.5 DATA COLLECTION

The procedures followed in order to prepare the study, conduct the pretests, implement the intervention and collect the data forms the focus of this section. This section commences with a tabular summary of the procedures. This is followed by a consideration of the pretest process, a detailed and systematic account of the intervention, the posttest events and the finalising of the study.

5.5.1 Procedure

Table 5.5 presents an overview of the procedures followed during the study. This overview is offered to assist in future replication of this study. Blankenship (2010:91) emphasises the importance of extensively documenting the time, process, place and people that will allow others to repeat or replicate the study. The process of replicating a study can be used to enhance the external validity of the study.

Table 5.5 Time Frame and Procedures of the Research Study

DATE	ACTIVITIES AND PROCEDURES
June 2010	• Initial contact with selected school • Presentation of proposed research to the school
July 2010	• Approval obtain to commence research study from Free State Education Department (Addendum F) • Approval obtain from the school principal to commence research (Addendum E)

September 2010	• Identification of the three classrooms to be included in the research • Teachers' and occupational therapist's morning to discuss proposed time frame, research design and intended intervention • Distribution of caregiver/parent consent forms and biographical questionnaires to teachers, hostel parents and therapists (to assist with collection of signed consent forms)
October 2010 – December 2010	• Collection of signed consent forms and biographical questionnaires (continue) • Collection of biographical data from school files • Researcher attended sign language classes to obtain the necessary background for more effective communication with children.
January 2011	• Collection of signed consent forms and biographical questionnaires (finalised) • Biographical data collection (finalised) • Pretest conducted at the school in individual setting o GMDS-ER (researcher and sign language interpreter) o NES (researcher and sign language interpreter) o CBCL (class teachers) • Random selection to form two equal groups • Finalised decision regarding developmental movement sequence as intervention method • Researcher attended additional sign language classes
February 2011 – May 2011	• Intervention (five days per week) with experimental group for 14 weeks with the researcher and occupational therapist (as assistant) • Placebo intervention (five days per week) with comparison group (activities with the researcher and occupational therapist as assistant)
June 2011	• Posttest data collection started in individual setting with both experimental and comparison groups under similar conditions to pretest o GMDS-ER (researcher and sign language interpreter) o NES (researcher and sign language interpreter) o CBCL (class teachers)
August 2011 – November 2011	• Comparison group received movement intervention (ethical responsibility) • School received reports on all children participating in study

Additional detail on the pretest, intervention and posttest procedures follows.

5.5.2 Pretest Procedures

The children were tested indoors and wore school tracksuits with comfortable sport shoes. There were items in the GMDS-ER and the NES where children were instructed to remove their shoes. Before testing commenced, a description and explanation of the procedure was given to each child in sign language. Participants were also asked if they would be willing to participate in the study. All children eagerly agreed. The pretest was administered according to the procedures for each measurement as discussed in the preceding section. Each child's information and data were kept in a separate plastic folder. The tests were done by the researcher (GMDS-ER and NES) and, where necessary, aid was given by a sign language interpreter who was present during the whole assessment with each child. A meticulous check was made to ensure that the children were free of illness and any other condition that could influence the tests and thus invalidate the assessment. The class teachers received a CBCL report form for each child and suitable time was allowed for the completion of the forms. Each class teacher felt comfortable with and understood how to complete the form after an individual information session was held. The researcher was available for questions or inquiries during this phase.

5.5.3 The Intervention: The Neurodevelopmental Movement Programme

The intervention included a movement programme in which activities were selected with the aim of ensuring learning readiness in the school beginner. The researcher reviewed and considered numerous movement-based programmes currently on offer worldwide, including the following:

- Holistic Approach to Neurodevelopment and Learning Efficiency (HANDLE®, 2011) in California, USA
- The Institute for Neuro-Physiological Psychology [INPP] reflex programme (INPP, 2011) in Chester, UK
- The Mind Moves® Institute (De Jager, 2009) in Johannesburg, South Africa
- The Move to Learn programme (Move to Learn, 2012b) in Sydney, Australia

The movement programme eventually chosen for the study derive from the '*Wired to*

Learn' programme from the Centre for Integrated Learning Therapy (Kokot, 2010a) in South Africa. The programme was selected as these movement activities are reported to help integrate retained primitive reflexes, give the brain another opportunity to structure neural networks needed for efficient functioning, assist in midline crossing, improve focus, handwriting and interhemispheric integration, all of which improves a child's general performance in daily living and school-related responsibilities (Kokot, 2010a:63, 86; 2011).

The *Wired to Learn* activities were strictly followed over a period of 14 weeks. As recommended by Kokot (2010a:88-89), the programme was offered once a day for 15 to 25 minutes, five days a week. The school occupational therapist was present during the implementation of the programme and was responsible for its implementing two days a week. The researcher attended the school for the other three days of the week and on those days was responsible for implementing the activities, monitoring each individual's progress and adapting movement activities as needed.

The programme was done at the school clinic during the first half of the morning before break time. The children that formed part of the experimental group were fetched from their classes and each class then formed their own group. There were two children in the Grade Pre-R class, three in the Grade R class and four in the Grade One class. The comparison group children were fetched in the same manner at a later stage during the morning, and in the company of either the researcher or occupational therapist took part in activities that included:

- Playing with clay
- Drawing pictures or painting
- Signing stories about the weather outside
- Playing outside on the jungle gym
- Throwing balls and walking over beams
- Signing the alphabet
- Building puzzles while being encouraged to do so as fast as they can
- Cutting out pictures

- Colouring in pictures
- Completing classwork worksheets
- Paging through magazines and story books
- Building with Lego blocks
- Learning about different body parts
- Free play
- Sorting beads according to different colours and shapes
- Relating stories about their weekend
- Writing numbers and the alphabet

The movement activities that were followed by the children in the experimental group were shown and modelled by the researcher and explained to the children with the help of the sign language interpreter. The movement activities were done in a specific order and the children in all three groups (according to their classes) began with the first activity and proceeded through all the activities in the order they are presented in the 'Wired to Learn' programme (Kokot, 2010a:88-89).

The movements are not meant to be done all at once. Each child began with the first activity and continued with it until they were able to do the movements with ease and automatically. As the researcher divided the experimental group into three smaller groups, the slowest child in the small class group needed to master an activity before the group moved on to the next activity. The slowest child therefore determined the progress through the programme of all the children in the group (Kokot, 2010a:87). Once all children were able to do the activities, the whole group moved on to the following activity. New activities were combined with the previously mastered activity for at least three weeks (Kokot, 2010a:87). The 'Wired to Learn' programme consists of ten main activities. Activities two, three, four, seven, eight and ten consist of more than one activity that can be viewed as a breakdown of the original activity into easier step-by-step movements. Table 5.6 lists these activities (Kokot, 2010a:89-108).

Table 5.6 The List of Activities of the 'Wired to Learn' Movement Programme

(Kokot, 2010a:88-89)

ACTIVITY NUMBER	ACTIVITY NAME
1	• Body Tucks
2	• Rollovers o Dung beetle on its back o Rollover soldier with head leading o Rollover soldier with hip leading o Full Roll
3	• Superman sequence o Caterpillar o Lazy days o Superman
4	• Flip Flops o Homolateral flip flops o Cross patterned flip flops o Cross patterned flip flops with added mental activity
5	• Crocodile
6	• Rocking
7	• The crawling sequence o The camel walk o The lion walk o Alternating the walks o Alternating the walks with added mental activity
8	• Standing sequence o Standing quietly in Romberg position o Changing posture
9	• Cross-pointing walk
10	• Cross-your legs walk o Forwards o Backwards o Eyes closed

Although the 'Wired to Learn' movement programme was implemented for 14 weeks, the children did not master all the activities, and not all ten activities were completed. The two children in the Grade Pre-R class mastered the activities up to Activity Three. The three children in the Grade R class and the four children in the Grade One class

mastered the activities up to Activity Four.

An example of the progress form used during the intervention programme for the experimental group appears in Addendum D. Each day, every child's progress on an activity was rated and marked accordingly on the progress forms. Participants scored ***1*** if they were unable to complete the activity, ***2*** if they partially managed the activity, and ***3*** if they mastered the activity and the movement was smooth and automatic. The researcher designed this rating system for two reasons: (1) it simplified the tracking of the participants' mastery of activities; and (2) it gave the researcher and the occupational therapist a way to communicate effectively as they alternated days that they were involved in implementing the programme. Children not present during group time were indicated as such by a line drawn through the three scores. Children occasionally missed sessions due to illness.

5.5.4 Posttest Procedures

The protocol followed in the pretest phase of the study was identical to the one used in the posttest phase. Before the start of the posttest phase, the researcher reacquainted herself with the administration and scoring procedures of each assessment.

5.5.5 Finalising the Research Project at the School

After completing the movement programme and the posttest assessment, all children in the comparison group were also offered the opportunity to take part in the intervention movement activities. This time the researcher, occupational therapist, and class teachers at the school were involved in the process. The researcher visited the school weekly to adjust activities and assist where needed. Most of the experimental group children freely joined the comparison group children during that time, but were not compelled to do so.

After the completion of the study, the headmaster, class teachers and the occupational therapist who assisted in the study were informed of the results. Brief explanations for the results were also provided, and a factual report of each child's developmental age as

determined by the GMDS-ER, and elevated clinical syndromes as determined by the CBCL was given to the school principal, with parental consent. The school decided to use the report results to plan individual interventions for those children in need of extra assistance.

5.6 DATA INTERPRETATION

The researcher hand-scored all the tests. The manuals for the GMDS-ER, CBCL/6-18 (TRF) and the CBCL /1½ - 5 (C-TRF) were used to score each specific test (Achenbach & Rescorla, 2000; Achenbach & Rescorla, 2001; Luiz *et al.,* 2004; Luiz, Faragher *et al*., 2006). The scoring protocols for each measurement were used to capture data during the collection phases, as well as to score the profiles of the children on both the GMDS-ER and the two versions of the CBCL. The NES was scored according to the scoring system adopted from the GABS from Thomas *et al.* (2004), and the INPP reflex scoring from Goddard (2005:86, 89, 90). The researcher developed a scoring system for the remainder of the NES test items (see Addendum C). The data were scored for both pre- and posttests and checked twice by the researcher. The school's occupational therapist rechecked the basic computation of total scores for all the measurements.

In order to interpret the data, all scores had to be transferred onto a consolidating scoring spread sheet. Care was taken that the scores were correctly copied, and were checked by both the researcher and the occupational therapist before data were finalised. The scoring spread sheet was divided into different columns for each measurement instrument to aid in the organisation and interpretation of the data.

The pre- and the posttest scores were compared to determine if the children showed any improvement from their pretest level of development, behaviour, and aspects of sensory-motor system functioning as measured by the chosen measurement instruments.

5.7 CONCLUSION

This chapter reviewed the purpose and hypotheses of the study and described the

planning process and execution of the empirical investigation. This was followed by a discussion of the chosen measurement instruments and the data collection procedure used in the empirical investigation. The particulars of the movement programme were described. The statistical techniques, methods of analysis, results of the statistical analysis, and interpretation of the results are presented in chapter six.

CHAPTER SIX

RESEARCH RESULTS AND INTERPRETATION

6.1 INTRODUCTION AND CHAPTER PREVIEW

The principal goal of this study was to implement, evaluate and design guidelines for a neurodevelopmental movement programme for four to eight year-old children with hearing impairment in a rural South African community. Based on this objective, the hypotheses stated in chapters one and five were formulated. To test the hypotheses, basic statistical techniques were applied to the pretest and posttest data. This chapter presents the findings of the data analysis.

The first section of the chapter focuses on the statistical techniques used to analyse the data. The second section describes the sample in detail. This description includes variables such as age and gender, family structure, comorbid disorders, and the like. The results of the data analysis are offered in the third section. The chapter concludes with a report of the results of certain tests in the form of a neurodevelopmental profile for this specific sample.

6.2 DATA ANALYSIS

Gravetter and Wallnau (2011:10) and Howell (2010:5) state that there are two primary divisions of the field of statistics, depending on how the data are used. These divisions are referred to as descriptive and inferential statistics. Both descriptive and inferential statistics were used to examine the research hypotheses in this study. The following subsections offer a short synopsis of these statistical techniques, followed by a description of the methods of analysis used in the study.

6.2.1 Descriptive Statistics

Descriptive statistics are used to describe the set of data by summarising, simplifying and organising the set of scores. This is typically done through graphs, calculation of the means (averages), and identification of extreme or oddly distributed scores. This provides some understanding about what the data have to say on a superficial level

(Gravetter & Wallnau, 2011:10, 614; Howell, 2010:5). Simple descriptive statistics calculated for the study include frequencies, means and standard deviations. Frequencies are the number of times a response has occurred (Gravetter & Wallnau, 2011:36). A mean is the sum of a set of scores divided by the number of scores (Howell, 2010:33). A standard deviation is a measure of the average of the deviations of each score around the mean (Howell, 2010:41).

6.2.2 Inferential Statistics

To confirm that the independent variable (the neurodevelopmental movement programme) did have an effect on the dependent variables (the performance on the various subscales or activities of the three measurements), the researcher used inferential statistics. Inferential statistics use sample data to reach general conclusions about a population (Gravetter & Wallnau, 2011:10).

An integral part of the interpretation of inferential statistics is the concept of ***statistical significance***. The null hypothesis provides the starting point for any statistical test (Howell, 2010:93). Statistical significance tests begin with the supposition that the null hypothesis (H0) is correct. The H0 states that there is no difference between the improvement shown by the experimental and the comparison groups. The alternative hypothesis states that the experimental groups improved more than the comparison group. When the data differ markedly from what we would expect if the H0 were true, we will simply reject the H0 and conclude that it is false (Howell, 2010:93). By concluding the H0 to be false, we are accepting the alternative hypothesis that the experimental group improved more than the comparison group, and that this change took place by something other than chance alone (Stangor, 2011:147).

Before the H0 may be rejected, the observed data must deviate substantially from what would be expected in the sampling distribution. The standard that the observed data must meet is known as the ***significance level*** or alpha (α) or the rejection level of the test. By convention, alpha is usually set to 0.05 (Stangor, 2011:147). One principle for rejecting H0 is that the probability under H0 is less than or equal to 0.05 ($p \leq 0.05$).

Another, more conservative principle is to reject H0 whenever the probability under H0 is less than or equal to 0.01 ($p \leq 0.01$) (Howell, 2010:96; Stangor, 2011:144, 147). One may therefore only reject H0 if the observed data are so unusual that they would have occurred by chance 5% ($p \leq 0.05$) of the time at most, or 1% ($p \leq 0.01$) of the time at most (Stangor, 2011:147). In other words, when a difference is statistically significant at the 0.05 level, it means that a difference of that size would occur in less than 5% of instances if H0 were true (Howell, 2010:96).

In this research study, H0 will be rejected whenever the probability obtained under H0 is less than or equal to the predetermined statistical significance level of 0.05. In all analyses, the 95% level of confidence ($p \leq 0.05$) was therefore applied as a minimum to interpret significant differences among sets of data.

6.2.3 Methods of Analysis

The statistical analyses addressed between-group and within-group effects among the experimental and comparison groups during the pretests and posttests. The analysis used a mixed model two-way repeated measures analysis of variance (ANOVA) to test whether changes over time were similar or different between the two groups. ***ANOVA*** is a hypothesis testing procedure used when two or more groups are being investigated. It is employed to ascertain significant differences between groups and to compare the means of dependent variables across the different levels (pre- and posttest) of the independent variable. This is done by analysing the variability of the dependent variable (Gravetter & Wallnau, 2011:366; Stangor, 2011:190-191). The two-way ANOVA allows one to evaluate the effect of two independent variables in one experiment, as well as the interaction between them (Pagano, 2012:446).

In essence, the ANOVA compares the variance of the means of the dependent variable between the different levels with the variance of individuals on the dependent variable within each of the conditions (experimental and comparison groups) (Stangor, 2011:191). The variance among the condition means is known as the ***between-group variance***, and the variance within the conditions is known as the ***within-group***

variance. If the between-group variance is significantly greater than the within-group variance, then we conclude that the intervention has influenced the dependant measure because the influence of the intervention across the levels is greater than the random fluctuation among individuals within the levels. For ANOVA, the test statistic is called an F-*ratio* and has the following structure (Pagano, 2012:406; Stangor, 2011:191):

$$F = \frac{\text{Between-group variance}}{\text{Within-group variance}}$$

The above ratio shows that F increases as the condition means differ more among each other, in comparison to the variance within the conditions. F has an associated p-value, which is then compared to alpha. In cases where the p-value is less than alpha, the null hypotheses are rejected (Stangor, 2011:191).

The following section describes the sample used in this study.

6.3 SAMPLE DESCRIPTION

As stated in chapter five, replicating a study can enhance external validity. In order for other researchers to replicate this study, a description of the sample who took part in the research study is given. Visual presentations in the form of bar charts and descriptive tables of the sample are provided. The sample consisted of eighteen children in total (N = 18). Nine children were in the experimental group and nine children in the comparison group. The children were numbered from one to eighteen. Children one to nine represented the experimental group and children ten to eighteen represented the comparison group. The following subsections describe the sample in terms of demographic information, family structure, historical and scholastic background, and intellectual functioning.

6.3.1 Demographic Information

The experimental and the comparison group were similar in terms of gender and age. As shown in figure 6.1, each group consisted of five boys and four girls per group.

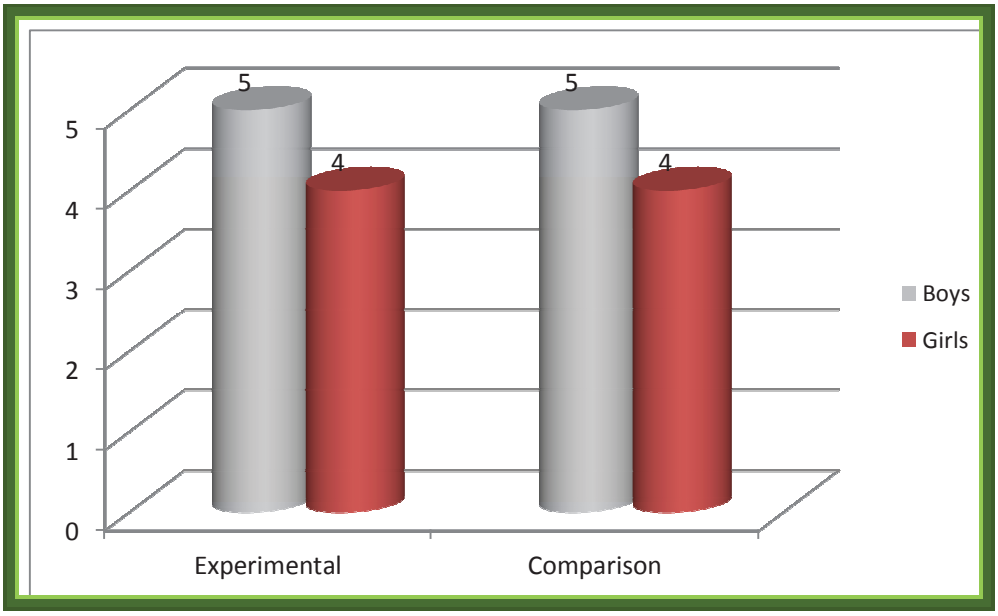

Figure 6.1 Gender Composition of the Sample (N = 18)

Gender frequencies were similar in the two groups. The female to male frequencies were 4:5 in both groups. Overall the gender ratio was 44.4% female to 55.5% male. The average age of the participants in each group is given in table 6.1. The children's age ranges from 4.6 years to 7.6 years at the pretest phase of the study.

Table 6.1 Descriptive Information on Age of the Sample (N = 18)

	n	Minimum	Maximum	Mean	Standard Deviation
Experimental Group – Pretest	9	55.5 months (4.63 years)	92 months (7.67 years)	78.78 months (6.57 years)	12.86 months (1.07 years)
Experimental Group - Posttest	9	60 months (5 years)	96 months (8 years)	82.83 months (6.9 years)	12.78 months (1.07 years)
Comparison Group – Pretest	9	70 months (5.83 years)	91 months (7.58 years)	81.61 months (6.8 years)	7.17 months (0.6 years)
Comparison Group - Posttest	9	74 months (6.17 years)	94 months (7.83 years)	85.22 months (7.1 years)	6.95 months (0.6 years)

The average age of participants in the experimental group at pretest which took place in

January 2011, was 6.57 years. The average age at posttest (June 2011) was 6.9 years. The average of participants in the comparison group at pretest was 6.8 years, and at posttest was 7.1 years. There was no statistically significant difference between the two groups [F (1,16) = 0.33306, p = 0.57] in terms of age and there was therefore no need to control for age in the analysis. Both groups were affected equally by age because the rule for significance ($p \leq 0.05$) was not met.

The grade composition of the participants in the experimental and comparison groups are presented in figure 6.2. The experimental group consisted of two Grade Pre-R, three Grade R, and four Grade One children. The comparison group consisted of two Grade Pre-R, four Grade R, and three Grade One children.

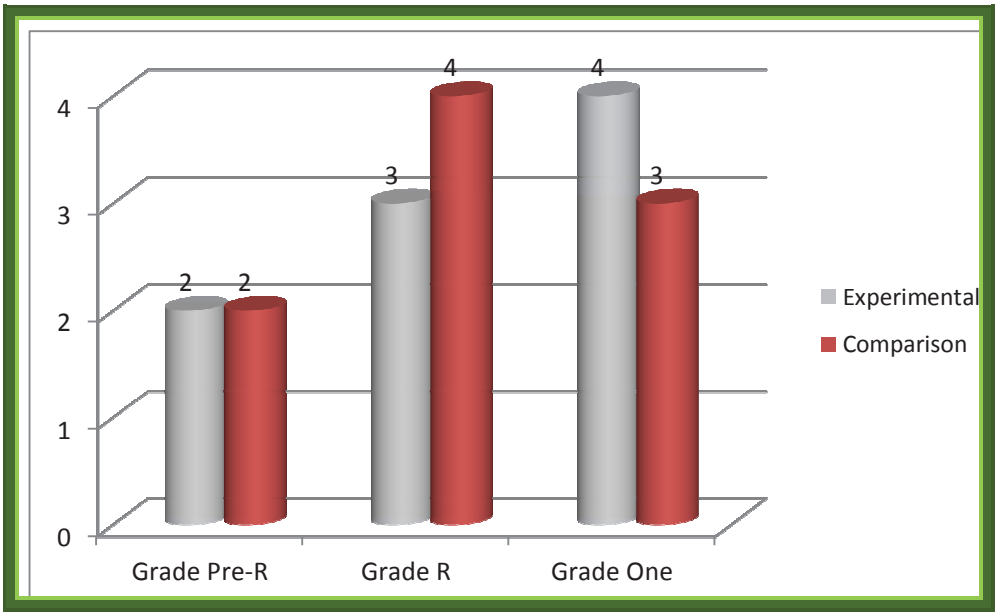

Figure 6.2 Grade Composition of the Sample (N = 18)

6.3.2 Family Structure

Information was obtained on aspects such as home language, parental marital status, cultural group and parent education level. This is presented below.

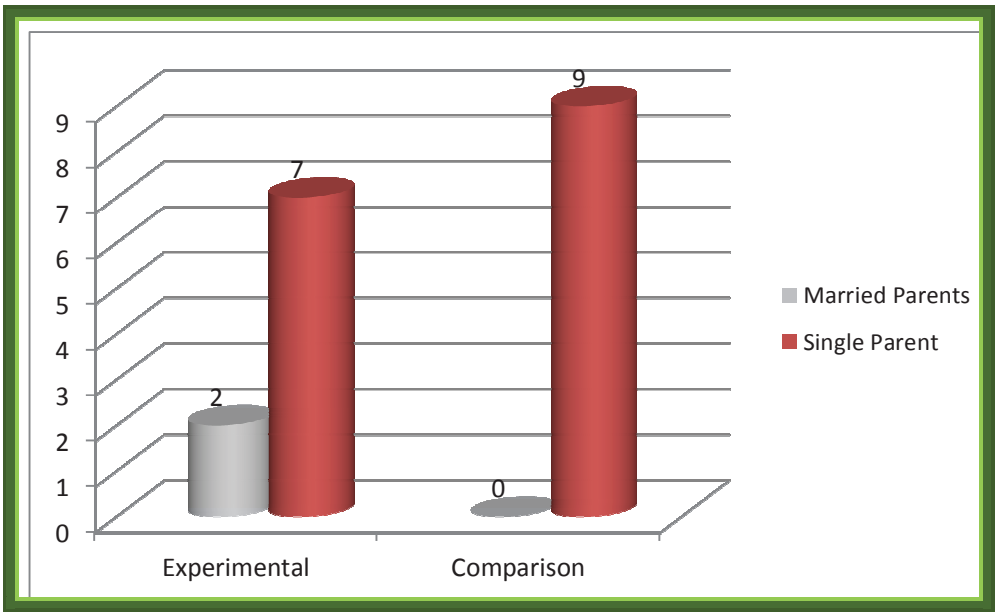

Figure 6.3 Family Structure of the Sample (N = 18)

Figure 6.3 shows that most participants were from single-parent families (seven in the experimental group and nine in the comparison group) and therefore had only one parent at home. The parents' level of education is given in table 6.2. Where participants lived with both their parents, the educational status of the parent with the highest level of education is indicated.

Table 6.2 Parents' Level of Education (N = 17)

	Grade 1 to 7	Grade 8 to 12	Apprenticeship	Post-matric (not university)	University training
Experimental Group (n = 8) *	2	6	0	0	0
Comparison Group (n = 9)	0	6	1	1	1

* No data were available for one of the children in the experimental group

Most parents had a grade eight to grade twelve level of education in both groups. Two of the parents in the comparison group continued with their education to post-matric and university level. The parents' employment status is shown in figure 6.4. In the two cases where the participants lived with both their parents, both parents were

unemployed, and this status is indicated as such.

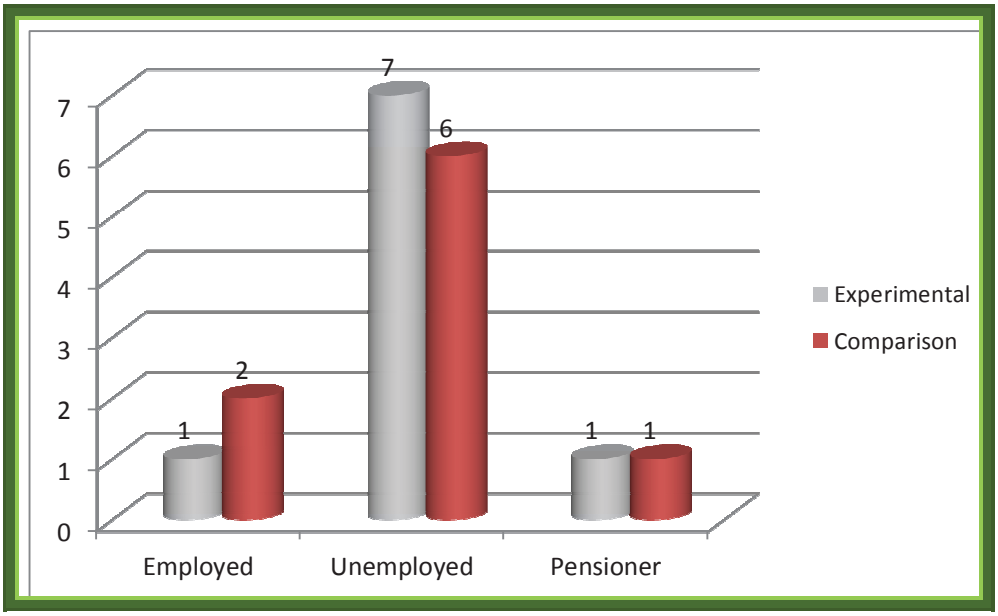

Figure 6.4 Employment Status of Participants' Parents (N = 18)

Both groups had one parent who received a monthly pension. Most parents were unemployed, while only one parent from the experimental group and two parents from the comparison group were employed at the time of the study.

Further details about the family units include the following:

- All the children in the sample were from a black cultural group.
- Only one of the 18 children in the sample grew up with sign language since birth as both his parents were also deaf. The remaining 17 children in the sample were all from Sotho-speaking households.

6.3.3 Historical and Scholastic Background

Information was obtained on participants' hearing impairment and scholastic background. Comorbid disorders are listed in table 6.3.

Table 6.3 Comorbid Disorders of Participants (N = 18)

	None	Other
Experimental Group (n = 9)	8	1 *
Comparison Group (n = 9)	8	1 #

* One child suffered from epilepsy and was HIV positive

One child was HIV positive

Most participants in each group presented with no comorbid disorders. The cause of the participants' hearing loss for each group is given in figure 6.5. Congenital causes were responsible for hearing loss in the case of two experimental group participants and one comparison group participant. Meningitis caused hearing loss in two experimental group and four comparison group participants. Causes were unknown for five experimental group and four comparison group participants.

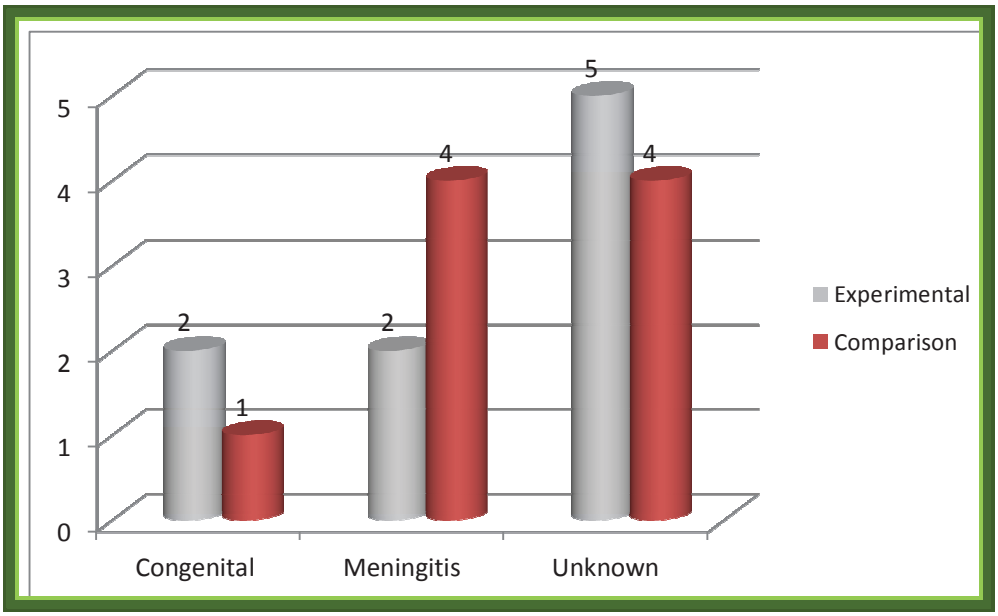

Figure 6.5 Cause of Participants' Hearing Loss (N = 18)

Figure 6.6 illustrates participants' age at diagnosis of hearing loss. This figure shows that 44.4% of participants were diagnosed in their first year (six experimental group participants and two comparison group participants), 22.2% during their second year (one in the experimental group and three in the comparison group), 22.2% during their

third year (two participants in each group) and 11.1% thereafter (two comparison group participants).

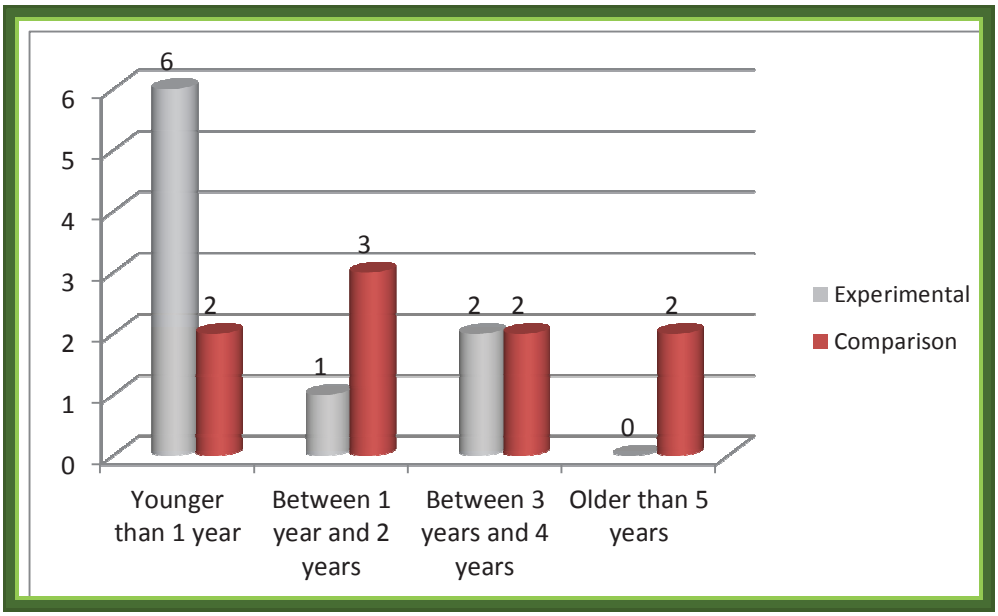

Figure 6.6 Participant Age at Diagnosis of Hearing Loss (N = 18)

In chapter two attention was drawn to research which emphasised the importance of early diagnosis of hearing loss for a child's overall functioning. In light of this, the above graph may create the impression that the experimental group participants may have a developmental advantage, because they were diagnosed earlier than most of the children in the comparison group. However, most of the comparison group participants acquired the hearing loss due to the contraction of meningitis. The later diagnosis was therefore not as a result of undetected hearing loss.

Figure 6.7 illustrates the age at which participants entered the school. Of the participants, 33.3% entered the school between the ages of three and four years (three children in each group), 22.2% between the ages of four and five years (two children in each group), 11.1% between the ages of five and six years (two experimental group participants) and 33.3% after the age of six years (two experimental group participants and four comparison group participants).

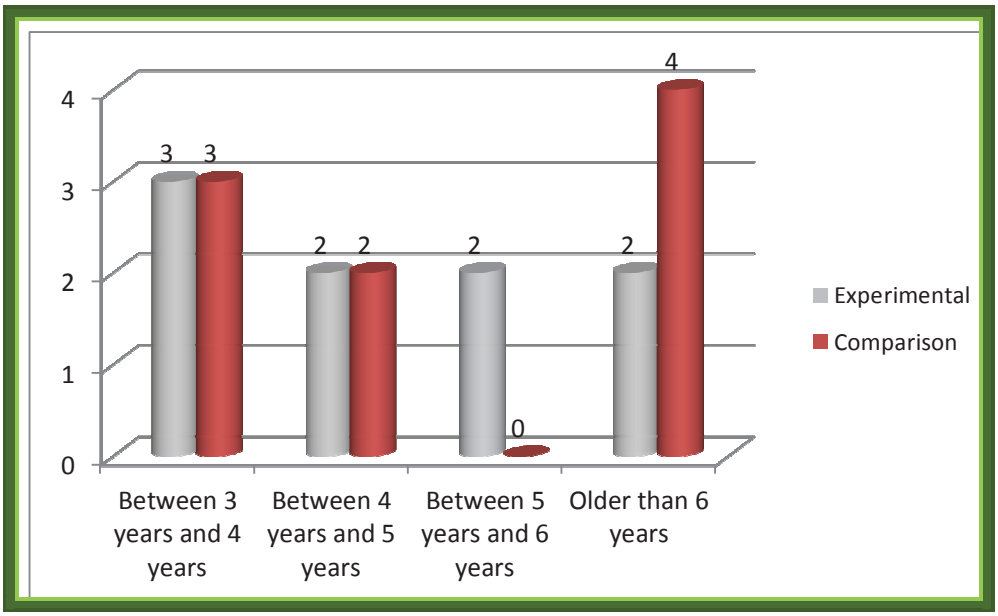

Figure 6.7 Participants' Age at School Entry (N = 18)

Further details on participants' historical and scholastic background include the following:

- None of the children made use of any form of amplification during the study.
- Seventeen of the 18 children experienced profound hearing loss. One child in the comparison group experienced severe hearing loss.
- All the children resided in the school hostel on the school premises over the course of the research project.

6.3.4 Developmental Presentation

At the start of the project, participants were evaluated in terms of general and specific aspects of development using the GMDS-ER. The two groups were equal in terms of their developmental functioning as presented in tables 6.4 and 6.5.

Table 6.4 Participants' General Developmental Level of Functioning (N = 18)

	Minimum	Maximum	Mean	Standard Deviation
Experimental Group (n = 9)	24 months	60.5 months	47.06 months	12.29
Comparison Group (n = 9)	31.5 months	56 months	46.17 months	7.66

The experimental group presented with an average general developmental level (developmental age) of 47.06 months at the onset of the research. The comparison group presented with an average developmental level (developmental age) of 46.17 months at the onset of the research. The difference between the two groups is not statistical significant at the 95% level of confidence ($p = 0.86$). As the two groups are fairly equal in terms of general developmental age, there was no need to control for this variable.

Table 6.5 Participants' Specific Developmental Levels of Functioning (N = 18)

	Locomotor Subscale (mean)	Personal-Social Subscale (mean)	Language Subscale (mean)	Eye-and-hand coordination Subscale (mean)	Performance Subscale (mean)	Practical Reasoning Subscale (mean)
Experimental Group (n = 9)	55.11 months	52.78 months	36 months	53.28 months	49.56 months	38.61 months
Comparison Group (n = 9)	56.44 months	52.89 months	34.89 months	53.94 months	45.28 months	37.89 months

Table 6.5 presents the specific developmental ages for both groups according to the six subscales of the GMDS-ER at the onset of the research. Again, the two groups were generally equal in terms of their specific developmental ages for each of the six subscales at the onset of the study. The differences between the developmental age of the two groups were not statistical significant at the 95% level of confidence for

- locomotor functioning (p = 0.87)
- personal-social functioning (p = 0.99)
- language functioning (p = 0.77)
- eye and hand coordination (p = 0.89)
- performance functioning (p = 0.57)
- practical reasoning functioning (p = 0.88)

No significant values of 0.05 or below were found. As the two groups were fairly equal in terms of specific developmental age for all GMDS-ER subscales, there was no need to control for these variables.

This section clarified that, at the start of the project, the experimental and comparison groups were similar in terms of severity of hearing loss, age, gender, parental employment status, cultural group, age of entry into formal schooling and developmental age. A significant uncontrollable variable was the separate classes. Variables that could affect the results included different class curriculums, teacher competencies and personality characteristics, as well as the competencies and personality characteristics of the class teacher's assistants. Care was taken to include children of all three classes in both groups to minimise the effect of these variables. Variables known to contribute to the child with hearing impairment's overall development include stimulation and interaction at home, and parental personality characteristics (Lim & Simser, 2005; Lynas, 2005; Marschark, 1993a:40; Sharma, Dorman & Spahr, 2002); however, none of these were considered in this study.

This section concludes the discussion on the description of the sample group. The following section considers the results of the statistical procedures performed on the data obtained from the pretest and posttest.

6.4 TESTING THE HYPOTHESES

At the onset of the study, the participants were tested with the three measures described in chapter five. This constitutes the pretest phase (Point A) of the project (refer to figure

6.8). After 14 weeks, the children were tested again. This constitutes the posttesting phase. By the posttest phase (Point B), the experimental group had received the intervention programme and the comparison group had received the placebo intervention.

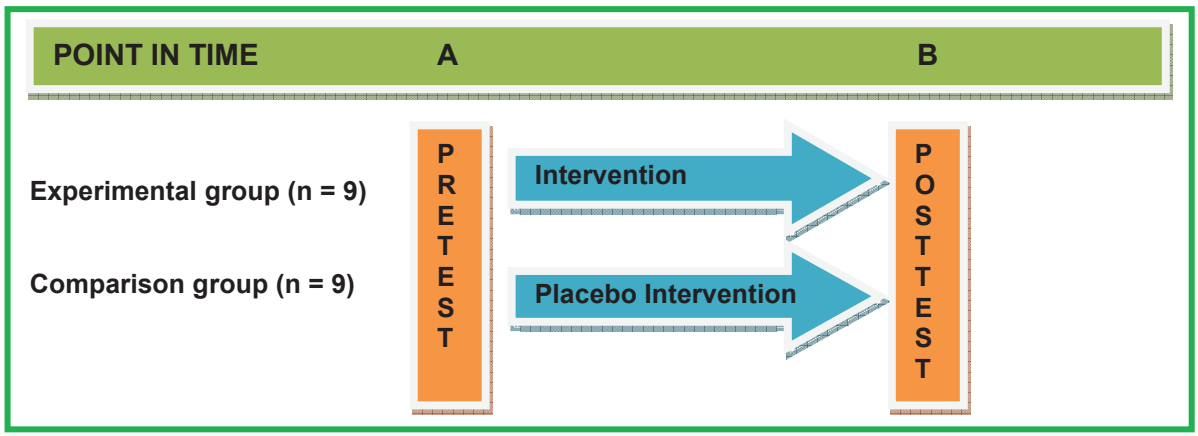

Figure 6.8 Representation of Analysis: Within-group and Between-group Effects

The approach followed to investigate the effect of the intervention programme was as follows:

- ***Between-group Interaction effect***: This effect was investigated by comparing the scores of the experimental group with those of the comparison group over time. The impact of the movement programme will be evident with a statistically significant Group*Time interaction effect on the GMDS-ER subscale scores, the syndrome subscale scores of the CBCL and the activity scores of the NES. No Group*Time interaction implies that any changes from pretest to posttest were the same for both groups. The null hypotheses will then not be rejected. This in turn implies that the movement programme did not have a statistically significant effect on the scores of that particular subscale or activity of a measure. If this interaction effect is significant, the within-group effect will be reported on.

- ***Within-group effect***: The possible effects of the neurodevelopmental movement programme were investigated by exploring whether the experimental group participants' developmental age, behavioural characteristics and specific

neurodevelopmental aspects had improved from the pretest (n = 9) to the posttest (n = 9), and whether the comparison group's (n = 9) scores had remained unchanged over the same period. The mean score of the experimental and comparison groups were examined at the pretest and posttest stages. Where the difference between the posttest and pretest score indicated improvement (as the hypothesis states), the improvement was tested statistically to determine if the differences between the two scores were significant.

- All improvements are indicated in ***bold*** in table format in the relevant subsections.

The results are discussed in terms of the three main hypotheses posed at the outset. The relevant aspects evaluated are development, behaviour, and neurodevelopmental performance. Subsection 6.4.1 deals with composite hypothesis one (H1), which is a comparison of the scores on the posttest and pretest on the GMDS-ER subscales scores. Subsection 6.4.2 deals with composite hypothesis two (H2), which is a comparison of the scores on the posttest and pretest on the CBCL syndrome scales scores. Subsection 6.4.3 deals with composite hypothesis three (H3), which is a comparison of the scores on the posttest and pretest of the NES activities scores.

6.4.1 Effect of the Programme on the GMDS-ER (H1)

The between-group interaction effect was investigated for composite H1 by comparing the scores of the experimental group with those of the comparison group over time. The results are indicated in table 6.6.

Table 6.6 Significance of Difference between Groups on the GMDS-ER (Interaction Effect)

Variable	Fixed Effect Test	Den. DF #	F	p
Total Developmental Age	Group*Time	16	10.75610	**0.004717 * ***
Locomotor Subscale	Group*Time	16	78.17559	**0.000000 * ***
Personal-Social Subscale	Group*Time	16	4.18356	0.057625
Language Subscale	Group*Time	16	0.01867	0.893022
Eye-and-Hand Coordination Subscale	Group*Time	16	1.32308	0.266942
Performance Subscale	Group*Time	16	5.159732	**0.037273 ***
Practical Reasoning Subscale	Group*Time	16	10.41908	**0.005260 * ***

Denominator degrees of freedom

* 5% level of significance ($p \leq 0.05$)

* * 1% level of significance ($p \leq 0.01$)

Table 6.7 presents the differences within groups on the GMDS-ER, along with the level of significance for those variables where the interaction effect was significant or where a trend was found.

Table 6.7 Significance of Difference within Groups on the GMDS-ER

Variable	Group	n	Pretest Mean	Posttest Mean	Mean Difference	p-value and significance
Total Developmental Age	Experimental	9	47.06	52.22	5.16	**p = 0.000004 * ***
	Comparison	9	46.17	47.83	1.66	**p = 0.042135 ***
Locomotor Subscale	Experimental	9	55.11	65.11	10.00	**p = 0.0 * ***
	Comparison	9	56.44	54.72	-1.72	p = 0.084843
Personal-Social Subscale	Experimental	9	52.78	58.89	6.11	**p = 0.001772 * ***
	Comparison	9	52.89	54.28	1.39	p = 0.407453
Performance Subscale	Experimental	9	49.56	59.72	10.16	**p = 0.001597 * ***
	Comparison	9	45.28	46.83	1.56	p = 0.569793
Practical Reasoning Subscale	Experimental	9	38.61	45.00	6.39	**p = 0.000834 * ***
	Comparison	9	37.89	37.17	-0.72	p = 0.649164

* 5% level of significance ($p \leq 0.05$)

* * 1% level of significance ($p \leq 0.01$)

Hypothesis 1:

H0: *The movement programme does not improve the experimental group's* ***development*** *significantly.*

Table 6.7 shows that there was a significant improvement between the posttest and pretest scores of the experimental group's ***general developmental age*** at the 1% level of significance ($p<0.01$). The statistical analysis also indicates that there was a significant improvement between the posttest and pretest scores of the comparison group's general developmental age at the 5% level of significance ($p = 0.042$). However, as shown in table 6.6, there was a significant interaction effect [$F(1, 16) = 10.76$, $p < 0.01$], which implies that improvement in the experimental group (5.16) was significantly more than in the comparison group (1.66). This means that the movement programme did have a statistical significant impact on the developmental age of the experimental group; and that the participants in the experimental group showed a

significantly greater increase in general developmental age scores than did participants who did not complete the programme.

Figure 6.9 illustrates this trend and presents a graphic of the data of the Group*Time interaction. It is displayed separately for the comparison group (red line) and the experimental group (blue line).

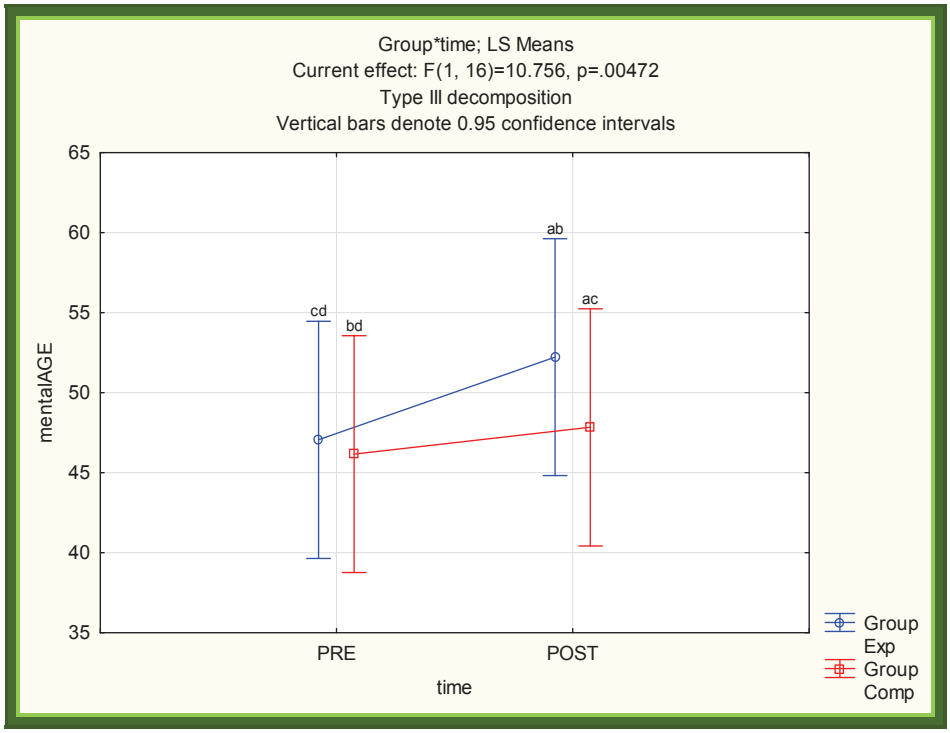

Figure 6.9 Group*Time Interaction According to the Developmental Age Subscale of the GMDS-ER

This graph shows the average scores of the experimental and comparison groups at the pretest and the posttest phase. For the pretest, both groups had fairly similar general developmental ages. Following the trend in the data of the experimental group (blue line), there was an increase between the pretest and the posttest, while the changes in the comparison group's scores did not show the same extent of difference. This trend is statistically significant at the 1% level ($p<0.01$).

The statistical results on each of the subscales of the GMDS-ER are discussed separately below.

Sub-hypothesis 1.1:

There are no statistically significant differences between the experimental group and the comparison group regarding the post- and pretest scores on the ***Locomotor*** *subscale of the GMDS-ER.*

Table 6.6 reveals that there was a statistically significant interaction effect between the experimental group and the comparison group over time (Group*Time interaction effect [F (1, 16) = 78.17559, p = 0.0). This means that the movement programme did have a statistically significant impact on the Locomotor subscale scores of the experimental group, and that the experimental group participants showed a significantly greater improvement than did participants who did not complete the programme.

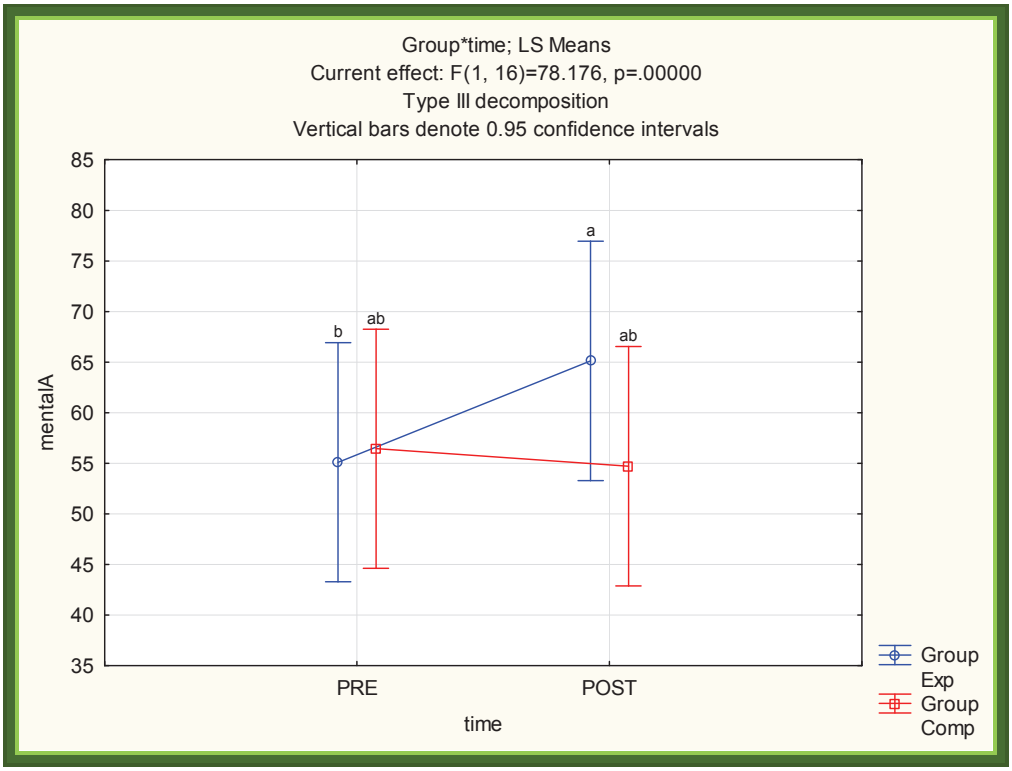

Figure 6.10 Group*Time Interaction According to the Locomotor Subscale of the GMDS-ER

Figure 6.10 illustrates this trend and presents a graphical display of the data of the Group*Time interaction. For the pretest, both groups had fairly similar general developmental ages. Following the trend in the data of the experimental group (blue line), there was an increase in locomotor developmental age between the pretest and

the posttest, while the changes in the comparison group's scores did not show any improvement. This trend is statistically significant on a 1% level ($p < 0.01$). Table 6.7 shows that there was a significant difference between the posttest and pretest scores of the experimental group's ***locomotor developmental age*** at the 1% level of significance ($p < 0.1$). The comparison group did not show any significant difference.

Sub-hypothesis 1.2:

*There are no statistically significant differences between the experimental group and the comparison group in terms of post- and pretest scores on the **Personal-Social** subscale of the GMDS-ER.*

Table 6.6 reveals that there was no statistically significant difference of the change over time between the experimental and comparison groups (Group*Time interaction effect [$F(1, 16) = 4.18356$, $p = 0.057625$), which means that the programme did not have a statistically significant impact on the participants' Personal-Social subscale scores. However, the p-value indicates that a trend was found, although this was not statistically significant at the 5% level. This might be because the sample size was relatively small, and the trend could as a result not be shown to be significant. Howell (2010:151) explains that with small sample sizes, power is more likely to be a problem. ***Power*** refers to the probability of correctly rejecting a false H0 when a particular alternative hypothesis is true (Howell, 2010:226). Increasing the sample size increases the power of this design (Howell, 2010:231).

Table 6.7 shows that there was a significant difference between the posttest and pretest scores of the experimental group's ***Personal-Social developmental age*** at the 1% level of significance ($p<0.01$). The comparison group did not show any significant difference between pretest and posttest scores on this scale.

Sub-hypothesis 1.3:

*There are no statistically significant differences between the experimental group and the comparison group in terms of post- and pretest scores on the **Language** subscale of the GMDS-ER.*

Table 6.6 revealed no Group*Time interaction, implying that any change from pretest to posttest was the same for both groups.

Sub-hypothesis 1.4:

There are no statistically significant differences between the experimental group and the comparison group in terms of post- and pretest scores on the ***Eye-and-Hand Coordination*** *subscale of the GMDS-ER.*

Table 6.6 revealed no Group*Time interaction, implying that any change from pretest to posttest was the same for both groups.

Sub-hypothesis 1.5:

There are no statistically significant differences between the experimental group and the comparison group in terms of post- and pretest scores on the ***Performance*** *subscale of the GMDS-ER.*

Table 6.6 reveals that there was a statistically significant interaction effect between the experimental group and the comparison group over time (Group*Time interaction effect [F (1, 16) = 5.159732, p = 0.03). This means that the movement programme did have a statistically significant impact on the Performance developmental age scores of the experimental group and that experimental group participants showed a significantly greater improvement than did children who did not complete the programme.

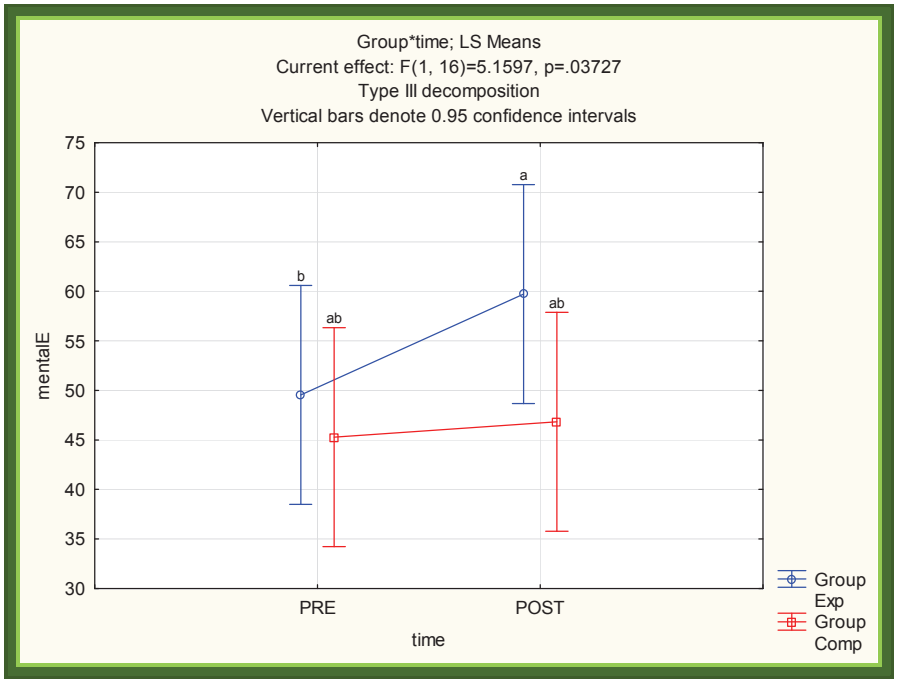

Figure 6.11 Group*Time Interaction According to the Performance Subscale of the GMDS-ER

Figure 6.11 illustrates this trend and presents a graphical display of the data of the Group*Time interaction. Following the trend in the data of the experimental group (blue line), there was an increase between the pretest and the posttest, while the changes in the comparison group's scores did not show the same trend. This trend is statistically significant at the 5% level ($p = 0.03$). Table 6.7 shows that there was a significant difference between the posttest and pretest scores of the experimental group's ***Performance developmental age*** at the 1% level of significance ($p < 0.01$). The comparison group did not show any significant difference in scores.

Sub-hypothesis 1.6:

There are no statistically significant differences between the experimental group and the comparison group in terms of post- and pretest scores on the ***Practical Reasoning*** *subscale of the GMDS-ER.*

Table 6.6 reveals that there was a statistically significant interaction effect between the experimental group and the comparison group over time (Group*Time interaction effect [$F (1, 16) = 10.41908$, $p = 0.005260$). This means that the movement programme did

have a statistically significant impact on the practical reasoning ability of the experimental group and that the experimental group participants showed a significantly greater improvement than participants who did not complete the programme. Figure 6.12 illustrates this trend in the data of the experimental group (blue line), showing the increase between the pretest and the posttest, while the changes in the comparison group's scores did not show any trend.

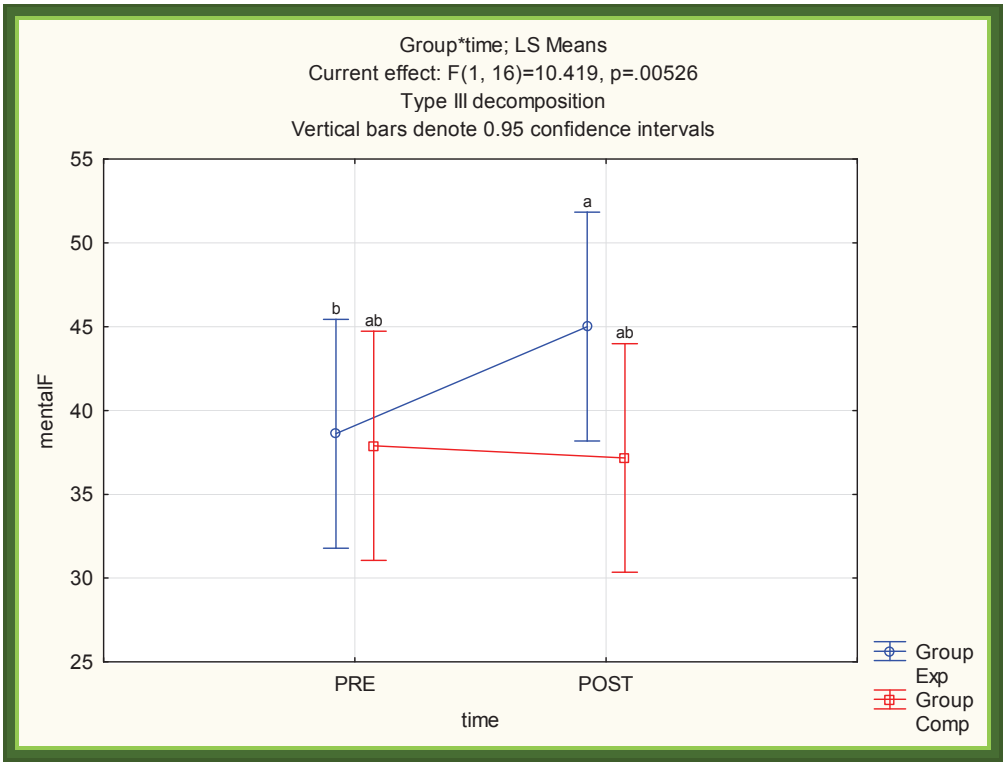

Figure 6.12 Group*Time Interaction According to the Practical Reasoning Subscale of the GMDS-ER

This trend is statistically significant on a 1% level ($p<0.01$). Table 6.7 shows that there was a significant difference between the posttest and pretest scores of the experimental group's Practical Reasoning developmental age at the 1% level of significance ($p<0.01$). The comparison group did not show a significant difference between pretest and posttest performance on this scale.

6.4.1.1 Summary of GMDS-ER Analysis

When comparing the mean scores of the two sets of test results (refer to table 6.7), the

averages were generally higher in the posttest than in the pretest. According to the scoring procedure, the better the performance on the subscales, the higher the scores. A higher mean in the posttest could thus indicate an increase in the developmental age of the child.

When looking at the interaction effect p-values given in table 6.6, the null hypothesis (H1) is rejected for the following variables:

- The Total Developmental Age ($p<0.01$)
- The Locomotor Developmental Age ($p<0.01$)
- The Performance Developmental Age ($p<0.05$)
- The Practical Reasoning Developmental Age ($p<0.01$)

In the following instances the null hypothesis is accepted:

- The Personal-Social Developmental Age ($p>0.05$)
- The Language Developmental Age ($p>0.05$)
- The Eye-and-Hand Coordination Developmental Age ($p>0.05$)

Null hypotheses are thus accepted for sub-hypotheses 1.2, 1.3 and 1.4. The null hypotheses for hypothesis 1, as well as for the sub-hypotheses 1.1, 1.5 and 1.6 are rejected as differences were statistically significant.

6.4.2 Effect of the Programme on the CBCL (H2)

The between-group interaction effect was investigated for composite H2 by comparing the scores of the experimental group with those of the comparison group over time. The results are indicated in table 6.8.

Table 6.8 Significance of Difference between Groups on the CBCL (Interaction Effect)

Variable	Fixed Effect Test	Den. DF #	F	p
Anxious / Depressed Syndrome Scale	Group*Time	16	0.127265	0.725946
Withdrawn Syndrome Scale	Group*Time	16	0.711311	0.411435
Somatic Complaints Syndrome Scale	Group*Time	16	0.898264	0.357344
Attention Problems Syndrome Scale	Group*Time	16	0.883219	0.361294
Aggressive Behaviour Syndrome Scale	Group*Time	16	0.035184	0.853568
Internalising Problems	Group*Time	16	0.407232	0.532406
Externalising Problems	Group*Time	16	0.115183	0.738732
Total Problem Scale	Group*Time	16	0.224256	0.642213

Denominator degrees of freedom

* 5% level of significance ($p \leq 0.05$)

* * 1% level of significance ($p \leq 0.01$)

Hypothesis 2:

***H0**: The movement programme does not change the experimental group's **behaviour** significantly.*

The ANOVA (see table 6.8) reveals that there was no statistically significant difference between the experimental group and the comparison group over time (Group*Time interaction effect) for ***Externalised, Internalised, and Total Problem subscales***. This means that the movement programme did not have a statistically significant impact on the participants' behaviour, and any change from pretest to posttest was the same for both groups.

The results on each of the subtests of the CBCL are discussed separately below.

Sub-hypothesis 2.1:

*There are no statistically significant differences between the experimental group and the comparison group in terms of the post- and pretest scores on the **Anxious / Depressed** syndrome scale of the CBCL.*

Table 6.8 revealed no Group*Time interaction, implying that any change from pretest to posttest was the same for both groups.

Sub-hypothesis 2.2:

*There are no statistically significant differences between the experimental group and the comparison group in terms of the post- and pretest scores on the **Withdrawn** syndrome scale of the CBCL.*

Table 6.8 revealed no Group*Time interaction, implying that any change from pretest to posttest was the same for both groups.

Sub-hypothesis 2.3:

*There are no statistically significant differences between the experimental group and the comparison group in terms of the post- and pretest scores on the **Somatic Complaints** syndrome scale of the CBCL.*

Table 6.8 revealed no Group*Time interaction, implying that any change from pretest to posttest was the same for both groups.

Sub-hypothesis 2.4:

*There are no statistically significant differences between the experimental group and the comparison group in terms of the post- and pretest scores on the **Attention Problems** syndrome scale of the CBCL.*

Table 6.8 revealed no Group*Time interaction, implying that any change from pretest to posttest was the same for both groups.

Sub-hypothesis 2.5:

*There are no statistically significant differences between the experimental group and the comparison group in terms of the post- and pretest scores on the **Aggressive Behaviour** syndrome scale of the CBCL.*

Table 6.8 revealed no Group*Time interaction, implying that any change from pretest to posttest was the same for both groups.

Sub-hypothesis 2.6:

*There are no statistically significant differences between the experimental group and the comparison group in terms of the post- and pretest scores on the **Internalising** scale of the CBCL.*

Table 6.8 revealed no Group*Time interaction, implying that any change from pretest to posttest was the same for both groups.

Sub-hypothesis 2.7:

*There are no statistically significant differences between the experimental group and the comparison group in terms of the post- and pretest scores on the **Externalising** scale of the CBCL.*

Table 6.8 revealed no Group*Time interaction, implying that any change from pretest to posttest was the same for both groups.

Sub-hypothesis 2.8:

*There are no statistically significant differences between the experimental group and the comparison group in terms of the post- and pretest scores of the **Total Problem** scale of the CBCL.*

Table 6.8 revealed no Group*Time interaction, implying that any change from pretest to posttest was the same for both groups.

6.4.2.1 Summary of CBCL Analysis

When comparing the mean scores of the two sets of tests results, it is noted that in general the averages were lower in the posttest than in the pretest. The scoring procedure determines that the less problematic the behaviour on the syndrome subscales, the lower the scores. A lower mean in the posttest could thus indicate a decrease in behavioural problems.

When looking at the interaction effect p-values given in table 6.8, the null hypothesis (H2) is rejected for no variables. In the following instances the null hypothesis is accepted:

- The Anxious/Depressed Syndrome scale ($p>0.05$)
- The Withdrawn Syndrome scale ($p>0.05$)
- The Somatic Complaints Syndrome scale ($p>0.05$)
- The Attention Problems Syndrome scale ($p>0.05$)
- The Aggressive Behaviour Syndrome scale ($p>0.05$)
- The Internalising Problems Syndrome scale ($p>0.05$)
- The Externalising Problems Syndrome scale ($p>0.05$)
- The Total Problem Syndrome scale ($p>0.05$)

Null hypotheses are thus accepted for hypothesis 2, as well as all sub-hypotheses 2.1 to 2.8, as no apparent differences were identified.

6.4.3 Effect of the Programme on the NES (H3)

The between-group interaction effect was investigated for composite H3 by comparing the scores of the experimental group with those of the comparison group over time. The results are indicated in table 6.9.

Table 6.9 Significance of Difference between Groups on the NES (Interaction Effect)

Variable	Fixed Effect Test	Den. DF #	F	p
Tandem Walk	Group*Time	16	10.0000	**0.006038 * ***
Manns Test	Group*Time	16	1.488372	0.240147
Fog Walk	Group*Time	16	1.565217	0.228888
Cross Pointing Walk [1]	Group*Time	df = 1	Wald Chi-Square = 2.36	Sig = 0.13
One Leg Stand	Group*Time	16	5.491525	**0.032355 ***
Eye Tracking	Group*Time	16	2.12890	0.163898
Convergence Activity	Group*Time	16	0.553846	0.467540
ATNR – Reflex	Group*Time	16	3.26115	0.089787
STNR – Reflex	Group*Time	16	0.507042	0.486676
TLR – Reflex	Group*Time	16	12.25000	**0.002964 * ***

Denominator degrees of freedom

* 5% level of significance ($p \leq 0.05$)

* * 1% level of significance ($p \leq 0.01$)

Table 6.10 presents the differences within groups on the NES, along with the level of significance for those variables where the interaction effect was significant or where a trend was found.

[1] Statistical analysis: Generalised estimating equations with binomial as underlying distribution

Table 6.10 Significance of Difference within Groups on the NES

Variable	Group	n	Pretest Mean	Posttest Mean	Mean Difference	p-value and significance
Tandem Walk	Experimental	9	1.67	1.11	-0.56	**p = 0.000385 * ***
	Comparison	9	2	2	0.0	p = 1.0
One leg Stand	Experimental	9	2.89	2.50	-0.39	**p = 0.020240 ***
	Comparison	9	3.00	3.11	0.11	p = 0.472112
ATNR – Reflex	Experimental	9	3.06	1.78	-1.28	**p = 0.002064 * ***
	Comparison	9	3.00	2.61	-0.35	p = 0.280354
TLR – Reflex	Experimental	9	2.00	1.00	-1.00	**p = 0.005793 * ***
	Comparison	9	1.79	2.33	0.56	p = 0.096162

* 5% level of significance (p ≤ 0.05)

* * 1% level of significance (p ≤ 0.01)

Hypothesis 3:

H0: *The movement programme does not change the experimental group's* ***performance on the neurodevelopmental evaluation*** *scale significantly.*

The NES does not calculate a total score for the ten activities. However, table 6.10 shows that there was a significant interaction effect between the two groups ***on three of the ten*** activities of the NES. These activities include:

- ***Tandem Walk*** at the 1% level of significance (p = 0.006038).
- ***One Leg Stand*** at the 5% level of significance (p = 0.032355)
- ***TLR reflex*** at the 1% level of significance (p = 0.002964)

The results on each of the items of the NES are discussed separately below.

Sub-hypothesis 3.1:

There are no statistically significant differences between the experimental group and the comparison group in terms of the post- and pretest scores on the ***Tandem Walk*** *activity*

of the NES.

The ANOVA (table 6.9) reveals that there was a statistical significant difference between the experimental group and the comparison group over time (Group*Time interaction effect [F (1, 16) = 10.00, p = 0.006038). This means that the movement programme did have a statistically significant impact on the Tandem Walk of the experimental group and that the experimental group participants showed a significantly greater increase in Tandem Walk scores than did participants who did not complete the programme. Figure 6.13 illustrates this trend and presents a graphical display of the data of the Group*Time interaction.

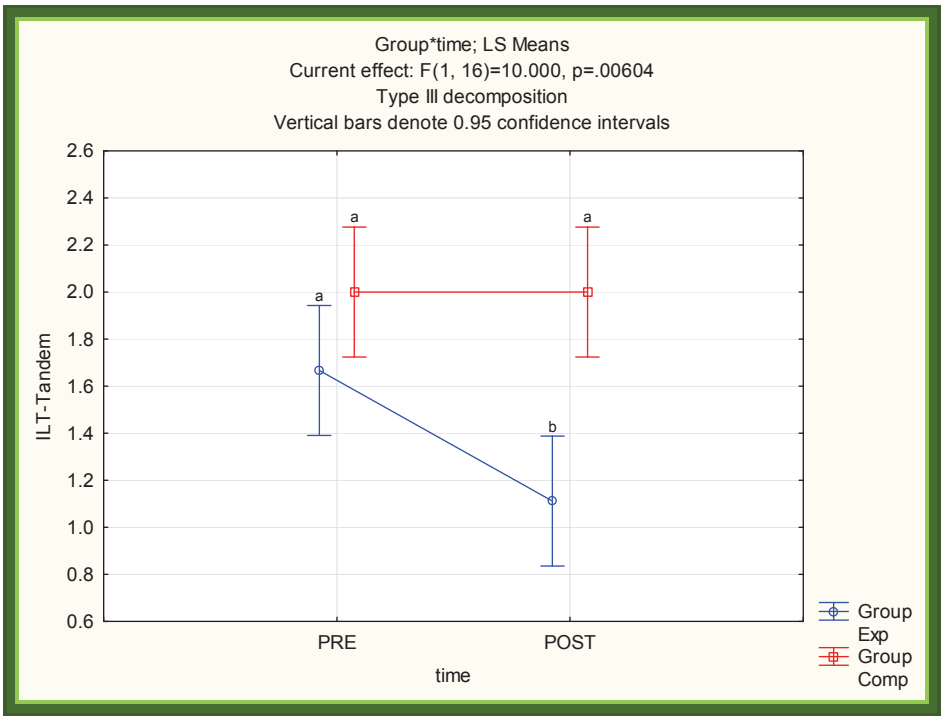

Figure 6.13 Group*Time Interaction According to the Tandem Walk Activity of the NES

This graph displays the average scores of the experimental and comparison groups at the pretest and posttest phase. At pretest, both groups had fairly similar Tandem Walk scores. Following the trend in the data of the experimental group (blue line), there was a decrease between the pretest and the posttest, while the changes in the comparison group's scores did not show any difference. This trend is statistically significant at a 1%

level ($p<0.01$). A decrease in Tandem Walk activity scores is indicative of an improvement. Table 6.11 shows that there was a significant improvement between the posttest and pretest scores of the experimental group's ***Tandem Walk*** at the 1% level of significance ($p<0.01$). There was no significant improvement between the posttest and pretest scores of the comparison group's Tandem Walk; indeed, there was no change at all.

Sub-hypothesis 3.2:

*There are no statistically significant differences between the experimental group and the comparison group in terms of the post- and pretest scores on the **Manns Test** activity of the NES.*

Table 6.9 revealed no Group*Time interaction, implying that any change from pretest to posttest was the same for both groups.

Sub-hypothesis 3.3:

*There are no statistically significant differences between the experimental group and the comparison group in terms of the post- and pretest scores on the **Fog Walk Test** activity of the NES.*

Table 6.9 reveals no Group*Time interaction, implying that any change from pretest to posttest was the same for both groups.

Sub-hypothesis 3.4:

*There are no statistically significant differences between the experimental group and the comparison group in terms of the post- and pretest scores on the **Cross-Point Walk** activity of the NES.*

Table 6.9 revealed no Group*Time interaction, implying that any change from pretest to posttest was the same for both groups.

Sub-hypothesis 3.5:

There are no statistically significant differences between the experimental group and the comparison group in terms of the post- and pretest scores on the ***One Leg Stand*** *activity of the NES.*

Table 6.9 reveals that there was a statistically significant difference between the experimental group and the comparison group over time (Group*Time interaction effect [F (1, 16) = 5.491525, p = 0.032355). This means that the movement programme did have a statistically significant impact on the experimental group's performance on the One Leg Stand and that the experimental group showed a significantly greater increase in competence in the One Leg Stand activity than did participants who did not complete the movement programme. Figure 6.14 illustrates this trend and presents a graphical display of the data of the Group*Time interaction.

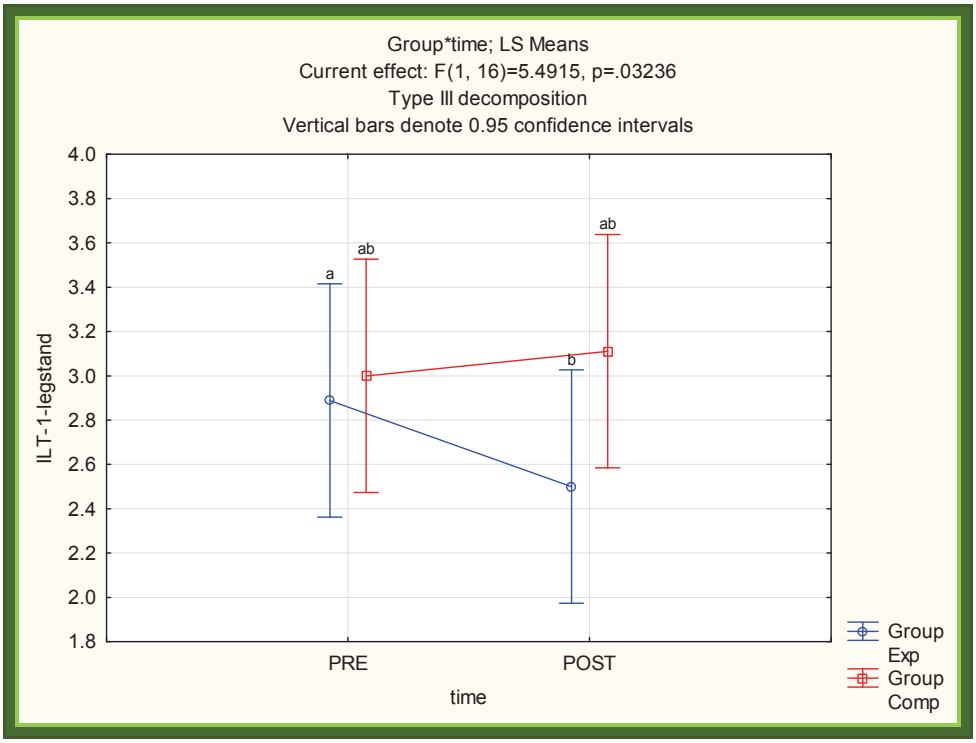

Figure 6.14 Group*Time Interaction According to the One Leg Stand Activity of the NES

For the pretest, both groups had fairly similar One Leg Stand scores. Following the trend in the data of the experimental group (blue line), there was a decrease between

the pretest and the posttest, while the changes in the comparison group's scores did not show the same extent of change. This trend is statistically significant at the 5% level (p = 0.03). A decrease in One Leg Stand activity scores is indicative of an improvement.

Table 6.10 shows that there was a significant improvement between the posttest and pretest scores of the experimental group's ***One Leg Stand*** at the 5% level of significance (p = 0.02). There was no significant improvement between the posttest and pretest scores of the comparison group's One Leg Stand.

Sub-hypothesis 3.6:

*There are no statistically significant differences between the experimental group and the comparison group in terms of the post- and pretest scores on the **Eye-Tracking** activity of the NES.*

Table 6.9 reveals no Group*Time interaction, implying that any change from pretest to posttest was the same for both groups.

Sub-hypothesis 3.7:

*There are no statistically significant differences between the experimental group and the comparison group in terms of the post- and pretest scores on the **Convergence** activity of the NES.*

Table 6.9 reveals no Group*Time interaction, implying that any change from pretest to posttest was the same for both groups.

Sub-hypothesis 3.8:

*There are no statistically significant differences between the experimental group and the comparison group in terms of the post- and pretest scores on the **ATNR** reflex of the NES.*

Table 6.9 reveals that a trend was found between the Group*Time interaction [F (1, 16)

= 3.26, p = 0.089). Figure 6.15 illustrates this trend. Following the trend in the data of the experimental group, there was a decrease in scores between the pretest and the posttest, while the comparison group's scores did not show the same extent of this trend. A decrease in ATNR scores is indicative of an improvement. However, this trend is not statistically significant at the 5% level (p > 0.05). Again, this might be because the sample size was relatively small, and the trend could therefore not be shown to be significant. By increasing the sample size, one may increase the power of this design (Howell, 2010:231).

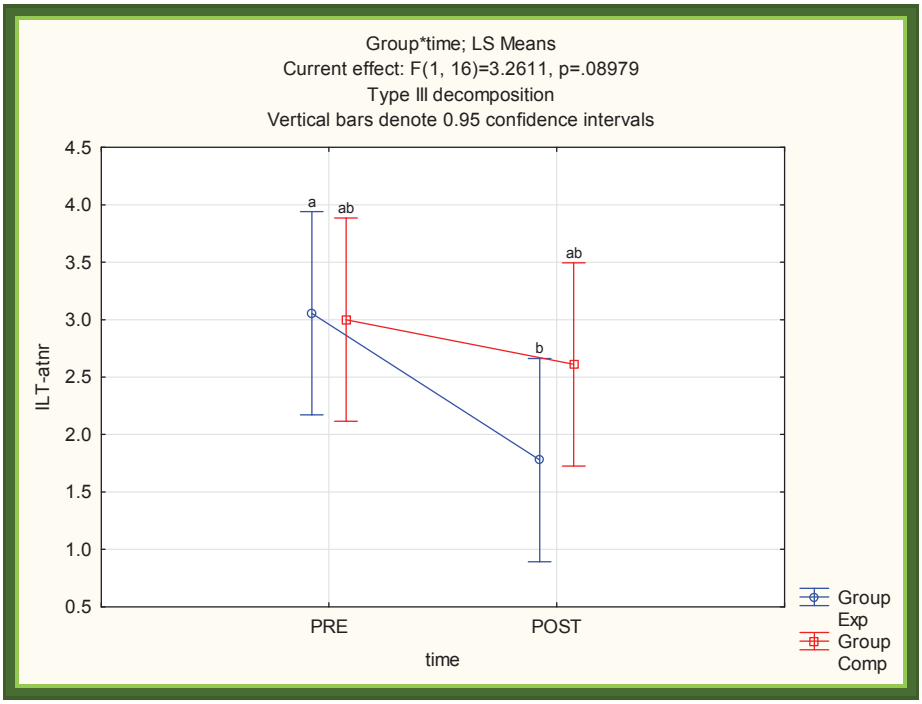

Figure 6.15 Group*Time Interaction According to the ATNR Reflex Activity of the NES

Table 6.10 shows that there was a significant improvement between the posttest and pretest scores of the experimental group's ***ATNR*** at the 1% level of significance (p<0.01). There was no significant improvement between the posttest and pretest scores of the comparison group's ATNR.

Sub-hypothesis 3.9:

*There are no statistically significant differences between the experimental group and the comparison group in terms of the post- and pretest scores on the **STNR** reflex of the*

NES.

Table 6.9 reveals no Group*Time interaction, implying that any change from pretest to posttest was the same for both groups.

Sub-hypothesis 3.10:

*There are no statistically significant differences between the experimental group and the comparison group in terms of the post- and pretest scores on the **TLR** reflex of the NES.*

The ANOVA (table 6.9) reveals that there was a statistically significant difference between the experimental group and the comparison group over time (Group*Time interaction effect [F (1, 16) = 12.25000, p = 0.002964). This means that the movement programme did have a statistically significant impact on the TLR reflex of the experimental group participants, and that this group showed a significantly greater decrease in their TLR reflexes than did participants who did not complete the programme. Figure 6.16 illustrates this trend and presents a graphical display of the data of the Group*Time interaction.

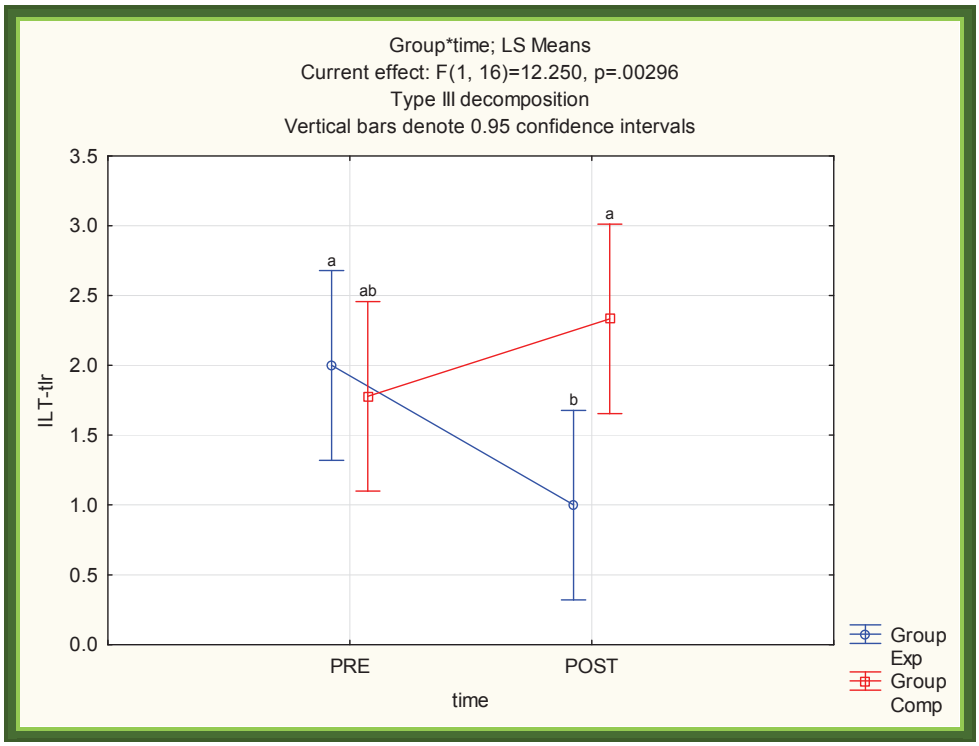

Figure 6.16 Group*Time Interaction According to the TLR Reflex Activity of the NES

This graph displays the average scores of the experimental group and comparison group at the pretest and the posttest phases. For the pretest, both groups had fairly similar TLR reflex scores. Following the trend in the data of the experimental group (blue line), there was a decrease between the pretest and the posttest, while the comparison group's scores increased between the pre- and posttest. This trend is statistically significant at the 1% level ($p<0.01$). A decrease in the TLR reflex score is indicative of an improvement. Table 6.11 shows that there was a significant improvement between the posttest and pretest scores of the experimental group's ***TLR reflex*** at the 1% level of significance ($p<0.01$). There was no significant improvement between the posttest and pretest scores of the comparison group's TLR; indeed, there was a change for the worse in the comparison group (increase in posttest scores indicates a poorer performance on this activity).

6.4.3.1 Summary of NES Analysis

When comparing the mean scores of the two sets of tests results, it is noted that in some cases the averages were higher, and in some cases the averages were lower in the posttest than in the pretest. The activities used to test the vestibular and the reflex system are such that a higher score represents reflexes no yet inhibited and difficulties with coordination and balance. A lower score represents reflexes that have been inhibited and fewer difficulties experienced in terms of coordination and balance. The test scoring indicates that the better the performance on the activities, the lower the score. A lower mean in the posttest could thus indicate a more integrated reflex and a better functioning vestibular system.

The activities used to test the visual system, on the other hand, are such that a higher score represents better eye tracking and convergence abilities. The better the performance on the activities, the higher the score. A higher mean in the posttest could therefore indicate a better functioning visual system.

When looking at the p-values given in table 6.10, the null hypothesis (H3) is rejected for the following variables:

- The Tandem Walk activity ($p<0.01$)
- The One Leg Stand activity ($p<0.05$)
- The TLR reflex ($p<0.01$)

In the following instances the null hypothesis is accepted:

- The Manns activity ($p>0.05$)
- The Fog Walk activity ($p>0.05$)
- The Cross Pointing Walk ($p>0.05$)
- The Eye Tracking activity ($p>0.05$)
- The Convergence activity ($p>0.05$)
- The ATNR reflex ($p>0.05$)
- The STNR reflex ($p>0.05$)

Null hypotheses are thus accepted for sub-hypotheses 3.2, 3.3, 3.4, 3.6, 3.7, 3.8 and 3.9. The null hypotheses for the sub-hypotheses 3.1, 3.5 and 3.10 are rejected as differences were statistically significant.

This section concludes the discussion on the hypotheses of the study. The last section of this chapter presents a report of the results in the form of a neurodevelopmental profile of this specific sample based on the results of the GMDS-ER and the NES.

6.5 RESULTS IN THE FORM OF A NEURODEVELOPMENTAL PROFILE OF THIS SPECIFIC SAMPLE

This section offers a graphical representation of the neurodevelopmental profile of the children with hearing impairment in this sample, derived from the ***mean developmental age*** on the subscales of the GMDS-ER before the implementation of the programme. The GMDS-ER provides a comprehensive profile, which highlights areas of development such as Locomotor and Personal-Social development, in addition to the child's cognitive and perceptual skills.

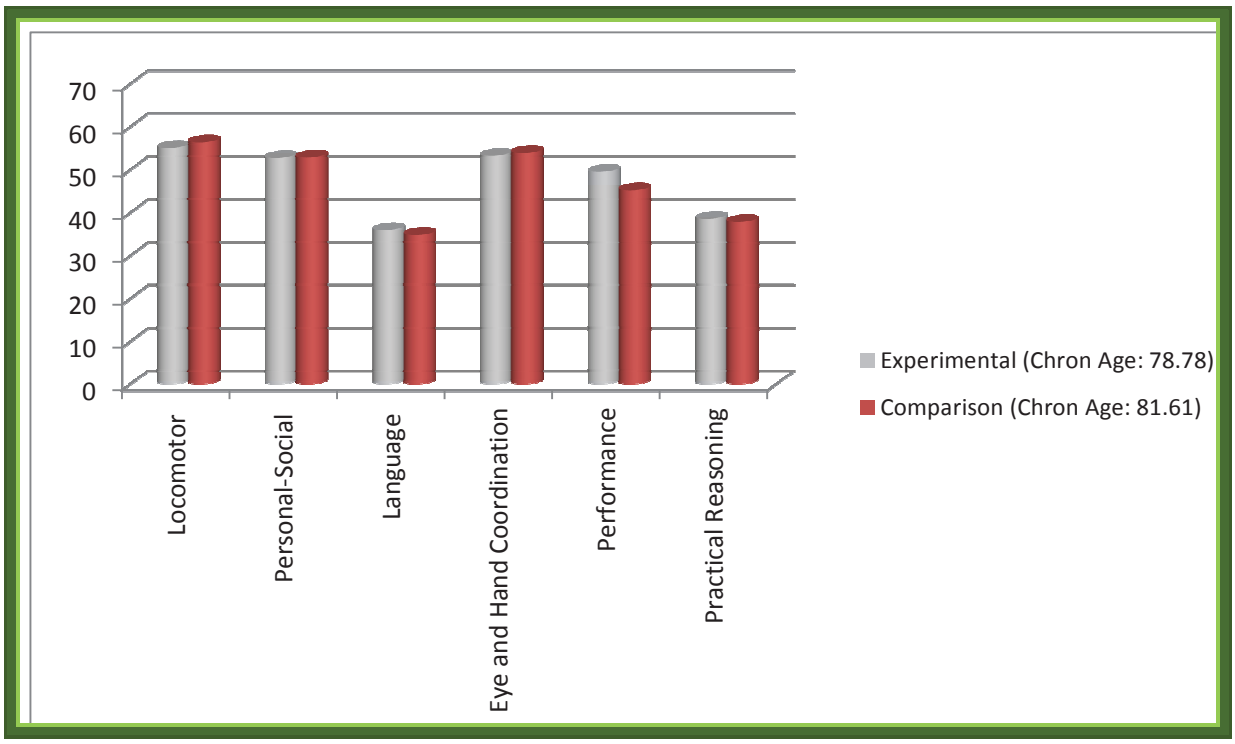

Figure 6.17 Hearing Impaired Profile (*developmental age in months on the GMDS-ER*)

The mean chronological age of the experimental group was 78.78 months, and the mean chronological age for the comparison group was 81.61 months. As mentioned in chapter three, the child with hearing impairment might be generally more prone to experiencing difficulties on the Language and Practical Reasoning subscales of the GMDS-ER. Figure 6.17 suggests that the profile of the current sample of rural children with hearing impairment is very similar to the findings reported in the literature review. Although an overall low developmental age was achieved on all subscales in comparison to the sample's chronological age, the lowest developmental ages were achieved on the Language and Practical Reasoning subscales of the GMDS-ER. Vocabulary and language skills are the basis for conceptual thought, which is assessed on the Practical Reasoning subscale (Schröder, 2004:133). The low scores of the sample on the Language subscale may therefore have impacted negatively on their performance on the Practical Reasoning subscale.

A tabular illustration (table 6.11) of the mean scores of the NES activities offers an alternative profile of the sample prior to implementation of the programme. The NES

provides a profile, which highlights areas of sensory-motor development such as vestibular, visual and reflex systems.

Table 6.11 Hearing Impaired Profile (mean activity scores on the NES)

NES Activity	Group	Pretest Mean
Tandem Walk		**0 (Normal) - - - - 1 (Impaired) - - - - 2 (Unable) ***
	Experimental	1.67
	Comparison	2
Manns Test		**0 (No difficulty) - - - 1 (Mild) - - - 2 (Moderate) - - - 3 (Severe) - - - 4 (Unable)**
	Experimental	3.22
	Comparison	3.89
Fog Walk		**0 (Normal) - - - - 1 (Impaired) - - - - 2 (Unable)**
	Experimental	1.56
	Comparison	1.56
Cross Pointing Walk		**0 (Normal) - - - - 1 (Impaired) - - - - 2 (Unable)**
	Experimental	1.78
	Comparison	1.89
One Leg Stand		**0 (No difficulty) - - - 1 (Mild) - - - 2 (Moderate) - - - 3 (Severe) - - - 4 (Unable)**
	Experimental	2.89
	Comparison	3.00
Eye Tracking		**0 (Poor tracking) - 12 (Perfect tracking)**
	Experimental	3.33
	Comparison	1.67
Convergence & Accommodation & Divergence		**0 (Poor) - - - - - - - - - - - - - - - - - 3 (Normal)**
	Experimental	1.78
	Comparison	2.22
ATNR Reflex		**0 (No response) - - 1 (Slight movement) - - 2 (45 °) - - 3 (60 °) - - 4 (90 °)**
	Experimental	3.06
	Comparison	3.00

STNR Reflex	Experimental	**0 (No response) - - 1 (Tremor) - - 2 (Movement) - - 3 (Bending) - - 4 ("cat" position)** 2.11
	Comparison	2.56
TLR Reflex	Experimental	**0 (No response) - - 1 (Slight) - - 2 (Disturbance) - - 3 (Near loss) - - 4 Loss)** 2.00
	Comparison	1.78

* See Addendum C for clarification of the scoring criteria of each activity

As mentioned in chapter four, children with hearing impairment might be more prone to experiencing vestibular impairment, problems with their visual system (specifically, referring to ocular motility and convergence difficulties), as well as aberrant ATNR and STNR reflexes. Table 6.11 indicates that the profile of the current sample of rural children with hearing impairment compares favourably with the findings presented in the literature review. All the participants experienced difficulties with the vestibular activities assessed, as well as with ocular motility activities. They also experienced aberrant ATNR, STNR and TLR reflexes.

6.6 CONCLUSION

The neurodevelopmental movement programme for children with hearing impairment yielded statistically significant results. In the quantitative analysis of the comparison group pretest-posttest design, it would appear to be that the participants who received the movement programme performed better than those who received the placebo intervention in terms of the Locomotor, Performance, and Practical Reasoning subscales, as well as on the general developmental age of the GMDS-ER. The participants who received the movement programme furthermore performed better in terms of the Tandem Walk, One Leg Stand, and TLR activities of the NES. The Personal-Social subscale of the GMDS-ER and the ATNR-reflex activity of the NES proved sensitive to the intervention programme of the study, although findings were not statistically significant.

Based on the results of the statistical analysis in the different subscales, several hypotheses were rejected. It is likely that the movement programme was the variable that contributed to the significant changes. However, the results must be considered with caution because of the relatively small size of the sample (N = 18).

A graphical and tabular representation was derived from the results obtained from the GMDS-ER and the NES in the form of a neurodevelopmental profile of this specific sample.

In chapter seven, results are discussed and evaluated, and integrated with the literature findings. Recommendations are made for future research and limitations of the study are also discussed.

CHAPTER SEVEN

LIMITATIONS, RECOMMENDATIONS AND CONCLUSIONS

7.1 INTRODUCTION

The statistical results of the study were reported in the previous chapter. In this final chapter, the results are discussed and integrated with the literature. Guidelines for programme designs, recommendations for future research, and the limitations of the study are discussed.

7.2 DISCUSSION OF RESULTS

Three composite research hypotheses guided the study. The findings related to each hypothesis are discussed below.

7.2.1 Improvement of Development

Hypothesis 1:

H0: The movement programme does not improve the experimental group's **development** significantly.

H1: The movement programme does improve the experimental group's **development** significantly.

The two groups were on the same developmental level before any interventions were implemented (table 6.4). Statistically significant improvements (table 6.6) were noted in the experimental group on some aspects of general development over a short period of 14 weeks, based on a standardised measurement (GMDS-ER). These improvements included *total developmental age, locomotor functioning, performance-related abilities*, and *practical reasoning*. Personal-social development proved sensitive to the intervention programme, but was not statistically significant. No statistically significant improvement was noted on the language development and eye-and-hand coordination skills of the experimental group.

A statistically significant improvement was noted in the total developmental age of the

comparison group who received the placebo intervention. The placebo intervention included activities such as playing with clay, drawing pictures, playing on jungle gyms, throwing balls, walking over beams, building puzzles and the like (see section 5.5.3). This result may support the critique against movement programmes, where the placebo effect is offered as the reason for change in children participating in movement programmes (Diamond, 2007:15; Goswami, 2006; Hyatt, 2007). The statistical results of this study do not indicate whether the children in the comparison group improved significantly because quality time was spent with them in doing activities of an educational nature, or whether the improvement was caused by the particular educational activities chosen during that time.

However, change over time in the experimental group was greater and statistically significant, suggesting that the movement programme's effect on general development was greater than that of the placebo intervention. The statistical analysis indicates that the comparison group's general development did benefit from the interaction with the researcher in a variety of everyday play and scholastic activities. However, the movement programme resulted in significantly greater improvement in the experimental group's general development. As there was a statistically significant improvement on the total developmental age of the experimental group, the ***stated hypothesis one (H0) is rejected***. The movement programme did therefore significantly improve the experimental group's developmental age.

Chapter three (see section 3.3.2) pointed out that coordination and the development of motor skills follows a particular sequence, namely, reflexes, gross motor and fine motor coordination (Gabbard, 1992:12, 221; Louw *et al.,* 1998:236–237; Nevid, 2007:348). Gross motor mastery thus depends on the successful development of reflex motor skills, and the development of fine motor skills depends on good gross motor development. It was furthermore indicated (see section 4.2.4.1) that a maturing vestibular function in children can be associated firstly with general motor development (Nandi & Luxon, 2008).

The study results suggest that the experimental group participants showed a significant improvement in locomotor skills (the GMDS-ER mainly assessed gross motor activities on this subscale – see table 5.2), but no significant improvement on the Eye-and-Hand Coordination subscale (mainly assessed fine motor skills – see table 5.2). In line with theory, the researcher concludes that the participants will have to develop facility in terms of primitive reflex integration and gross motor skills before the fine motor abilities will improve. As the participants did not successfully complete all ten activities of the planned movement programme, it is also possible that the 14 week programme should have been extended with a few weeks to allow additional time for developing fine motor skills.

Chapter three (see section 3.3.2.2) highlighted that motor development affects cognitive development and can enhance a child's understanding of what his or her body is capable of doing (Louw *et al.,* 1998:238). The statistically significant results shown on the Performance and Practical Reasoning subtests of the GMDS-ER can therefore be ascribed to the effects of the movement programme.

While the participants were being assessed on the GMDS-ER, it was noted that 11 of the 18 children (61.11%) in the sample were left-handed. The literature notes that left-handedness is more often represented among children with deafness than among their hearing counterparts. It has been suggested that left-handedness is an indicator of laterality in the hearing impaired and right-ear advantage in normal hearing populations (Dane & Gumustekin, 2002; Ittyerah & Sharma, 1997). During the course of the study, however, the researcher noticed that although sign language conversation requires the use of both hands, many of the early signs used to communicate to the young children at the school required only one hand. These include, specifically, signs used to teach children the alphabet and the spelling of their names, as well as basic question signs such as: 'why', 'where', 'who', and 'what'. Keeping in mind that teachers sign with their dominant hand during these one-handed signing tasks (which, in the case of these teachers, was always the right hand), the researcher questions the possibility that the children at this school may have been mirroring the teachers while learning those signs.

As a result they sign more with their left hands, subsequently becoming more prone to being left-handed. The reason that children younger than six or seven years old mirror movements is because they still have little knowledge of directionality (Cheatum & Hammond, 2000:102). Kokot (2007b:3) adds that in cases where there is poor left-right discrimination, children will hold up the left hand as if they are mirroring the person in front of them, when that person is holding up the right hand). The researcher recommends further study to explore this phenomenon in children with hearing impairment.

7.2.2 Improvement of Behaviour

Hypothesis 2:

H0: The movement programme does not change the experimental group's **behaviour** significantly.

H1: The movement programme does change the experimental group's **behaviour** significantly.

There was no statistical significant difference (see table 6.8) over time between changes in the experimental and comparison groups. This indicates that the movement programme did not have a statistical significant impact on the participants' behaviour. For this reason ***the stated hypothesis two (H0) is accepted***.

In the pretest phase, six of the nine children (66.6%) in the experimental group had total *CBCL* scores falling within the normal range. Two children's total *CBCL* scores fell in the clinical range and one in the borderline range. Six of the nine children (66.6%) in the comparison group had total *CBCL* scores that fell within the normal range, with one child in the clinical range and two children in the borderline range. During the posttest phase all children in the comparison group had total *CBCL* scores within the normal range, while eight of the nine children in the experimental group had total *CBCL* scores in the normal range. Only one child in the experimental group fell within the clinical range. None of these differences was statistically significant.

At the start of the study, a relatively large percentage of children in both groups presented with no specific behaviour problems (according to syndrome scales on anxiety/depression, withdrawal, somatic complaints, attention difficulties, and aggressive behaviour). As a result, there were few opportunities for improvements in behaviour improvements in this sample. This may explain the nonsignificant result obtained on this measure.

7.2.3 Improvement on the Performance of the Neurodevelopmental Evaluation

Hypothesis 3:

H0: The movement programme does not change the experimental group's **performance on the neurodevelopmental evaluation** scale significantly.

H1: The movement programme does change the experimental group's **performance on the neurodevelopmental evaluation** scale significantly.

Statistically significant improvements (see table 6.10) were noted in the experimental group on some aspects of neurodevelopment. These improvements were noted in the *vestibular system (Tandem Walk and One Leg Stand)*, as well as in the *reflex system (TLR-reflex).* The ATNR-reflex proved sensitive to the intervention programme, although the result was not statistically significant.

No statistically significant improvements were noted on the Manns Test, Fog Walk (Vestibular system) and Cross Pointing Walk activities. No statistically significant improvements were noted on the Eye Tracking and Convergence activities (visual system) or on the STNR-reflex (reflex system) for the experimental group.

Sub-hypothesis 3.1 **(Tandem Walk**), sub-hypothesis 3.5 (**One-leg Stand**), and sub-hypothesis 3.10 (**TLR-reflex**) are therefore ***rejected***. The following sub-hypotheses are ***accepted:*** 3.2 ***(Mann's Test),*** 3.3 ***(Fog Walk),*** 3.4 ***(Cross-Point Walking),*** 3.6 ***(Eye-Tracking),*** 3.7 ***(Convergence),*** 3.8 ***(ATNR-Reflex), and*** 3.9 ***(STNR-reflex).***

As mentioned in chapter four (see section 4.2.4.1), the adequate functioning of lower

level systems, such as the vestibular system, has the most influence on other sensory systems and the daily functioning of the child (Cheatum & Hammond, 2000:143; Goddard, 2005:56; Hannaford, 2005:38). This may explain the effect of the movement programme on the statistically significant results shown on the vestibular system activities (Tandem Walk ($p < 0.01$), and One Leg Stand ($p < 0.05$)), as well as on the reflex system activity (TLR-reflex ($p < 0.01$)). Maturing vestibular function in children may be associated with general motor development (especially pertaining to posture) (Nandi & Luxon, 2008). The improved vestibular functioning was evident in the significant results on the Locomotor subscale of the GMDS-ER.

No statistically significant results was found for visual system functioning. Some of these aspects are considered to be abilities which will only improve once the lower level systems are functioning optimally. Visual system functioning is reliant on the effective functioning of the vestibular system. Aberrant ATNR, TLR, and STNR-reflexes can also have adverse effects upon visual tracking and convergence (Goddard, 2005:73).

In line with theory, the researcher concludes that the learners may need to develop further with regards to primitive reflex integration and vestibular system functioning before the systems higher up in the developmental hierarchy will show improvement. As the participants could not successfully complete all ten activities of the planned movement programme, it is also possible that more significant results may be obtained if the movement programme is implemented over a longer period of time. Although the ten activities of the movement programme could not be completed during the 14-week implementation phase of the study, the results on the NES indicate that significant results could be achieved for lower-level systems (such as the reflex system and the vestibular system) within a relatively short timeframe, and through completing only some of the ten activities.

The movement programme intervention and the research project as a whole is evaluated in the next section by selecting, adapting and integrating several of the steps from the programme outcome evaluation plans proposed by Grinnell, Gabor and Unrau

(2012:173) and Smith (2010:40).

7.3 PROGRAMME AND STUDY EVALUATION

Programme evaluation, in general, refers to a process in which research methods are used to assess programmes (Smith, 2010:20) and investigate the effectiveness of intervention programmes (Rossi, Lipsey & Freeman, 2004:16). Programme evaluation is important as it helps to clarify and describe how the intervention works, which goals it is pursuing and how the programme is monitored and assessed (Smith, 2010:5).

A programme ***outcome evaluation*** plan particularly evaluates a programme's objectives (Grinnell *et al.,* 2012:169; Smith, 2010:33), level of success, and its usefulness and failures (Smith, 2010:35). A programme outcome evaluation is also often referred to as a programme ***impact evaluation*** (De Vos, 2005c:369; Rossi *et al.,* 2004:58), which evaluates whether it was the programme that caused the intended outcomes or improvements (Rossi *et al.,* 2004:58; Smith, 2010:36). Henry (2010:128) integrates the two concepts and explains that the impact of a programme is to compute the difference between the outcomes of the experimental group after participating in the programme and the outcomes of the comparison group after not participating in the programme. By evaluating a programme's objectives, one is, in effect, testing hypotheses about how one thinks a participant will change after a period of time in the programme (Grinnell *et al.,* 2012:170).

If an intervention programme has clearly defined goals or objectives, the first step in an outcome evaluation is nearly achieved. A programme's objectives should be tied to theory. As such, the programme outcome evaluation should be driven by theory (Grinnell *et al.,* 2012:174). The "*Wired to Learn"* programme used in this study consisted of selected movement activities with the objective of helping to integrate retained primitive reflexes, structuring neural networks needed for efficient functioning, assisting in midline crossing, improving focus, handwriting and interhemispheric integration, all of which improves a child's general performance in daily living and school-related responsibilities (Kokot, 2010a:63, 86; 2011). In essence the *"Wired to*

Learn" programme's main objective is to "*ensure learning readiness in the school beginner"* (see section 4.2.4) (Kokot, 2010a:1). The selection of the movement activities in the programme based on theoretical principles that were discussed extensively in chapter four (see sections 4.2 & 4.3).

Grinnell *et al. (*2012:174) explain that all data collected should directly relate to a programme's objectives. Selecting the best measures for a programme's objectives is a critical part of an outcome evaluation (Grinnell *et al.,* 2012:175). The researcher used two standardised measuring instruments (GMDS-ER and CBCL) with high reliability and validity (see sections 5.4.2, 5.4.3). A third nonstandardised measuring instrument, the NES, was also used (see section 5.4.4). All measuring instruments were selected in order to collect data on variables based on the programme's objectives. The researcher took great care to quantify the clinical observations of the NES, as well as to describe each item in sufficient detail in order to give the variable a measured operational definition (Myers & Hansen, 2012:204).

The GMDS-ER and CBCL contained groups of questions and activities that together directly assessed the programme's main objective of '*ensuring learning readiness'.* The GMDS-ER provided information on the sample's general development (locomotor functioning, personal-social skills, language abilities, eye-and-hand coordination skills, performance skills and practical reasoning abilities). The CBCL provided information on the sample's overall behaviour (anxious/depressed behaviour, withdrawn behaviour, somatic complaints, attention problems and aggressive behaviour). The influence of sensory-motor functioning on a child's social behaviour (in particular, self-esteem, body image, sport-related abilities, activity levels, ability to sit still, social skills) were documented in chapter four (sections 4.2.4.1, 4.2.4.3, 4.2.4.4). The NES contained clinical observational items that directly related to the functioning of the sensory-motor subsystem of the neurological system and therefore directly provided data that assessed the programme's objectives of integrating primitive reflexes, improving midline crossing and promoting interhemispheric integration.

A quantitative method was used to measure the objective measureable variables of change of scores on the GMDS-ER, the CBCL, and the NES. According to Henry (2010:125), a comparison group design is frequently employed to assess the impact of programmes on their intended outcomes. In this study a comparison group pretest-posttest design was selected. The experimental group outcomes were compared to those of the comparison group, whose programme included activities that may ordinarily have occurred in the absence of the programme. By contrasting the outcomes of the two groups, the researcher was able to estimate the impact of the programme on its intended outcomes. Great care was exercised to minimise the effects of threats to external and internal validity (cf. 5.3.3). Care was particularly taken to ensure as much equivalence as possible between the two groups.

It is advisable to collect data from as many participants as possible in an outcome evaluation (Grinnell *et al.,* 2012:177). A randomised design is also desirable when doing programme impact evaluations (Rossi *et al.,* 2004:297). A nonprobability purposive sampling technique was selected for this study and random sampling could therefore not take place. However, participants were randomly assigned to the two groups, evenly distributing possible bias and therefore not unduly affecting the outcomes of the study (Clark-Carter, 2010:46; Macnee & McCabe, 2008:129). The sampling method and the small sample size prevent the researcher from generalising the findings beyond this sample. When reporting the findings of nonrandomised quasi-experimental impact assessments, Rossi *et al.* (2004:238, 296-297) state that it is vital to point out clearly that the effect estimates might be biased. The authors add that there is some evidence that, under favourable circumstances and when carefully done, quasi-experiments can yield estimates of programme effects that are comparable to those derived from randomised designs. The quasi-experimental design is therefore still useful for an impact assessment when it is impractical or impossible to conduct a true randomised experiment (Rossi *et al.,* 2004:238). As such, the results of this study may still be generalised to theory (Gratton & Jones, 2004:103).

This study demonstrated the effectiveness of a movement programme in improving

locomotor functioning, performance-related abilities, practical reasoning, as well as TLR-reflex integration and enhanced vestibular system functioning in a sample of children with hearing impairment in the rural South African QwaQwa region over a 14-week period. Results of this research correlate with findings of other studies on the effect of movement and learning in South Africa. De Jager (2005:330) found qualitative evidence that the BrainGym® programme yielded positive results on key concepts such as visual midline crossing, eye-and-hand coordination, logic and gestalt brain integration, self-image, mathematical computation and concentration. Fredericks *et al.* (2006) found similar significant differences in the pretest and posttest results of the academic skills of Grade One learners after the implementation of a movement programme. Likewise, in a study conducted by Van der Westhuizen (2007:354–355), a significant difference was found in the levels of concentration of children after the implementation of an ecosystemic approach (of which a movement programme formed part). A study done by Gouws (2009:82) demonstrated that a kinderkinetic programme can improve levels of motor proficiency, as well as scholastic performance and classroom behaviour. Another recent study (Krog, 2010:94) generated useful information which contributes to a clearer understanding of the role of movement programmes in helping a child achieve learning readiness.

No or limited financial outlay is required to implement this programme. The usual preschool media, including an open space with comfortable flooring is available not only in an equipped preschool but also in rural preschools with limited resources. The programme is cost-effective in terms of resources and time, and is easy to implement. The study shows that a movement programme in a group with a sample with hearing impairment can be successful. It is innovative, can be implemented by the class teacher, and enables rural children with hearing impairment to receive help in enhancing learning readiness.

The study furthermore indicated that the GMDS-ER and the NES can be successfully used in compiling a neurodevelopmental profile for this specific sample. The developmental profiles compiled using these measures were similar to findings

presented in the literature review in terms of the most typical developmental concerns of children with hearing impairment, suggesting that they are valid. Neurodevelopmental profiles can serve as a valuable guide to educational and rehabilitation professionals who are involved in planning intervention programmes for rural children with hearing loss as they provide information on the general development, as well as sensory-motor and reflex development of these children. This study showed that the movement programme improved some of the areas of concern highlighted in the neurodevelopmental profile.

At the outset of the study, the literature review identified neurodevelopmental delays as being barriers to learning. For children to actualise their potential, barriers to learning need to be eliminated as much and as soon as possible. It can be concluded that this programme has the potential to improve learning readiness in a sample of rural children with hearing impairment; that it can supplement the school curriculum for learners with deafness; and that it may be useful in the hearing impaired educational setting.

This research study was not completed without limitations and possible influence of variables. It will be the focus of the following section.

7.4 INFLUENCE OF VARIABLES AND LIMITATIONS OF THE STUDY

Certain variables may have influenced the results of the study. These include the following:

- *Methodological shortcomings:*
    - A methodological weakness was the use of a nonprobability purposive sampling technique. The limitations of this sampling procedure are that external validity might be limited and the results might not be representative of the general population. The findings and conclusions of this study are preliminary and should be duplicated in other settings to allow for representative findings.
    - Although children were randomly assigned to both groups, the groups differed somewhat on certain uncontrollable variables. These variables

included teacher characteristics, teacher competencies, different class curricula and parental style variation.

- The small sample size (N = 18) is a drawback in the study as the results are not necessarily generalisable. The sample cannot be considered representative of the total diverse rural population with hearing impairment of South Africa. The fact that the school from which the sample was drawn included only 18 children who fitted the criteria for this study limited the possibility of drawing a larger sample. Nonetheless, despite the small sample size, the study still revealed reliable and statistically significant results, which provide directions for future research on this topic.
- There is a lack of recent literature and more specifically peer reviewed academic and empirical research on the topic of movement programmes, the impact of these programmes on higher order development, as well as the influence of sensorimotor programmes on specific populations. It would have been valuable to include more recent literature and evidence base of movement programmes in this study. Nevertheless, the results of this study contributed to the building of theory with regards to the possible benefit of movement programmes within a limited time span on this particular group of children.

- *Neurodevelopmental and measuring instrument considerations:*
  - Chapter three noted that individual neurological development and natural maturation occur at different rates for each individual. Children reach milestones at their own pace. External and internal factors can affect a child's development, and may therefore also influence individual progress made on the neurodevelopmental movement programme.
  - Although the two standardised measuring instruments (GMDS-ER and CBCL) have been used on populations with deafness before and are supported by extensive evidence of validity and reliability, these measurements have not been standardised for a population with deafness.
  - Although the researcher diligently selected the activities for the NES, it is

important to note that this is a nonstandardised screening measurement. Currently, there are no standardised measuring instruments pertaining to the assessment of sensory-motor systems.

- Chapter five indicated that sensory-motor systems develop according to a hierarchical order; and that for a child to experience success in learning, a number of sensory-motor systems need to be functioning well (Kokot, 2003b:15). This factor may have been responsible for the nonsignificant differences noted in some of the dependent variables measured.
- Other potential possibilities which could have influences on the results of this study are that the movement programme could not be completed in its entirety; and that it was implemented over a relatively short period of time (14 weeks).

Based on the limitations discussed in this section, recommendations for future research are made in the next section.

7.5 SUGGESTIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

- *Recommendations for future research include the following:*
  - Longitudinal studies are needed on the potential benefits of movement programmes for children with a hearing impairment. The concept of disorganisation before reorganisation which, according to Van der Westhuizen (2007:319), is common in sensory integration interventions may shed new light on nonresponders.
  - Randomised experiments with a larger sample of children with hearing loss will provide estimates of the programme effects of a more generalised nature.
  - Possible samples could include children with hearing impairment from both rural and urban areas, and those with and without hearing impairments. Different groups of children may respond differently to the movement programme and might yield interesting results on the development of sensory-motor systems of the child with hearing impairment in particular.

- When replicating this research study for external validity purposes, the duration of the intervention should be extended to maximise its possible positive effects. The pre- and posttests should furthermore preferably be done by independent test users with no information as to which group the children belong to.
- Studies focussing on the development of a standardised neurodevelopmental scale would be valuable in assessing sensory-motor functioning for future research.
- This study identified a trend suggesting that the movement programme may enhance personal-social functioning and decrease retained ATNR-reflexes in these children. These trends were not conclusive; and replication of the study could assist in refining this finding. Further research into these trends may also optimise knowledge and understanding of the link between movement programmes and personal-social development, and provide additional insight into the integration of primitive reflexes in children with hearing loss.
- Future studies focussing on the reason for change after implementing a movement programme by examining alternative frameworks could enhance the objectivity of conclusions drawn.
- This study offered results of certain tests in the form of a neurodevelopmental profile for this specific sample. Further research into whether rural children with hearing impairment in general shows similar profiles with regards to test results will be valuable.

- *Educational recommendations include the following:*
  - Movement forms the basis of all development and is considered an essential key to learning readiness, early academic achievement, as well as neurological development. Rural children with hearing loss do not only suffer from a sensory deficit, but also undoubtedly lack access to the healthcare professionals to the same degree as people in urban areas. This highlights the gravity of providing a movement programme which

could serve as a cost-effective way to enhance essential learning for this group of children.

- It is recommended that the essential role of movement in the neurological development of the child be emphasised in schools, especially schools for the hearing impaired. More time should be set aside for daily movement programmes in the early years of school, which may help improve the child with hearing impairment's degree of learning readiness.
- As part of the initial educator's training, more emphasis should be placed on the importance of movement in the overall development of a child with hearing loss.

- *Recommendations for using the "Wired to Learn" movement programme in deaf educational settings include the following:*
  - The movement programme should commence in the first term of the school year to increase the possibility that children will be able to progress through all ten activities over the course of the school year. In this way, children may reap the full benefits of the programme.
  - Teachers or facilitators of this programme should not only explain the activities by means of sign language, but should be willing to demonstrate the activities to the learners themselves or show them a video snippet of the activity to enhance their understanding of what is expected. The "*Wired to Learn*" movement programme consists of video material of each activity to assist the facilitator in understanding what is expected. The same video material can be shown to the children to show them the correct way of completing the activity.

7.6 CONCLUSION

The overreaching aim of this study was to implement, evaluate, and to design guidelines for a neurodevelopmental movement programme for four to eight year-old children with hearing impairment in a rural area. The rural child with hearing loss is at risk for learning problems as a result of their sensory deficit, and due to inadequate remediation and

assistance to overcome this barrier. Accordingly, the need is becoming more urgent to investigate supplementary and better solutions. In this study a neurodevelopmental movement programme aimed at enhancing learning readiness was implemented and the outcome evaluated. Although all ten activities of this programme could not be fully completed during the 14-week implementation phase, the results suggest that the programme shows promise in enhancing the rural child with hearing impairment's overall development.

Some aspects of specific development showed significant improvements following the intervention, such as locomotor functioning, performance-related abilities, and practical reasoning skills. General developmental age showed significant improvement in both the experimental and the comparison group, although the change was significantly greater in the experimental group. No behaviour aspects showed significant improvements, although significant improvement was identified in some aspects of neurodevelopment, such as the vestibular system (Tandem Walk and One Leg Stand) and the reflex system (TLR –reflex).

This research study contributes, ***firstly***, to a beginning point for professionals to consider movement programmes as part of the daily curriculum of preschool and early foundation phase for learners with hearing loss. ***Secondly***, the research indicated that overall development is promoted by all kinds of educational and physical stimulation within a recognised preschool programme, as the comparison group also improved significantly after receiving the placebo intervention. ***Thirdly***, the results of the pretest and posttest data provide constructive assistance in understanding the impact of movement programmes on a child with a hearing disability's general development and neurodevelopmental development. ***Fourthly***, the results obtained from implementing the "*Wired to Learn*" programme with a sample of rural children with hearing loss proved that neurodevelopmental movement programmes can be explained to children with deafness in sign language, can be implemented through adequate demonstration, and can add value to the child with hearing impairment's school curricula. ***Fifthly,*** the researcher hopes that the neurodevelopmental profile for this specific sample will

contribute to knowledge of the nature of the challenges faced by the child with hearing loss in rural education, the neurodevelopmental origin of these challenges, and an approach to helping overcome them. ***Lastly***, the study highlights the need for South African educational institutions and schools to consider the importance of movement programmes as means to learning readiness in current teaching programmes for learners with hearing loss in rural areas.

This research adds to the limited availability of quantitative research on this controversial topic, which is usually regarded as pseudoscience.

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ADDENDUM A

Covering Letter and Consent Form

A NEURODEVELOPMENTAL MOVEMENT PROGRAMME FOR 4 – 8YRS OLD HEARING IMPAIRED CHILDREN IN THE RURAL QWAQWA REGION, SOUTH AFRICA

CONSENT FORM

Researcher: Mrs. Jó-Marié Bothma
P.O. Box 1088
HARRISMITH
9880
Tel: 072 725 1661 (office hours)

Dear Parent / Caregiver September 2010

Regarding:…….(Child's name)……..……(DOB)

The Hugenote College in support with the ***school's name**** plan to conduct a research project evaluating a neurodevelopmental movement program. This study was evaluated and approved by the ethics committee of the Hugenote College[1] and the Education Department of the Free State.

Despite South Africa being a country where a significant number of infants and children are hearing impaired, to date, limited research has been conducted on a neurodevelopmental movement program as a form of early intervention. For this reason it is necessary to accumulate knowledge about the development and implementation of such a program so as to assist in future recommendations.

We are writing to ask for your permission to allow your child (name above) to take part in this research project, which involves an assessment on the Griffiths Scales of Mental Development, a behaviour checklist and a neurodevelopmental scale. During this assessment which takes approximately one to two hours, children are asked to complete a number of age appropriate tasks, such as building bricks, throwing a ball and drawing and naming pictures. Teacher will also be asked to rate your child's behaviour. The assessment will take place at the school during the period of January 2011 to June 2011 at a time, which the teachers have allocated to us. The assessments will not interfere with your child's education. Thereafter, children will be randomly divided into either an experimental group or a comparison group. Those in the experimental group will partake in a 14-week neurodevelopmental movement program. During this program, which takes approximately 15 –

[1] This research study commenced at the University of South Africa (UNISA) and Hugenote College. The study was completed at the North West University (NWU), when Hugenote College integrated with NWU.

25 minutes per day, children will take part in activities such as rolling activities and tummy crawling. These activities will be implemented in the mornings after breakfast, and before official class starts and will not interfere with your child's education. Those in the comparison group will be allowed to play freely or do classwork under the watchful eye of a caring adult. After the completion of the 14-weeks program, your child (name above) will be reassessed. Those children in the comparison group will also then be given the opportunity to participate in the neurodevelopmental movement program, once the reassessment has taken place.

There will be no personal costs involved and upon completing the research. The principal of your child's school will receive a written report regarding your child's performance. You will have access to that report. The assessment results will be used for research purposes and all information will be treated as strictly confidential. If you are agreeable for you child to take part in this project, we would be grateful if you could complete the enclosed consent from and return it to the school as soon as possible. If you wish to obtain further information about this project please contact us at the telephone numbers provided below. If you do not wish your child to take part in this project, please indicate this on the consent form and you will not be contacted again. There would be no prejudice against children whose parents refuse to participate in this study.

We would like to stress that the success of this project depends on your consent and we sincerely thank you in anticipation.

Yours sincerely

Mrs. J. Bothma
Cell: 072 725 1661
Clinical Psychologist & Researcher
jvdm@jbothma.co.za

Dr. Munita Dunn
Tel: 021 – 873 1181
Counselling Psychologist and Promotor
Deputy Director: Centre for student communities
University of Stellenbosch
mdunn@sun.ac.za

A NEURODEVELOPMENTAL MOVEMENT PROGRAMME FOR 4 – 8YRS OLD HEARING IMPAIRED CHILDREN IN THE RURAL QWA-QWA REGION, SOUTH AFRICA

DECLARATION BY PARENT / CONSENT FORM

Please complete the relevant sections:

Child's Full name:……

Child's Date of Birth:……..

Gender: Male/ Female

Parent's telephone number:…….

I, THE UNDERSIGNED,……..……(parent's name)

[I.D. No:…….] from…….……..

……..…….

……..…….(address).

Please complete Section A or Section B:

Section A:

HEREBY CONFIRM AS FOLLOWS:

1. My child was invited to participate in the abovementioned research project which is being undertaken by Mrs. J. Bothma of the Department of Play therapy, Hugenote College and UNISA.
2. That I have read and understand the information letter regarding the abovementioned research project.
3. This research project aims to address this dearth in research by evaluating a neurodevelopmental movement program on hearing impaired / deaf children from the **school's*

*name**. The information will be used as part of the requirements for a Doctorate study in the field of psychology. The results of this study may be presented at scientific conferences or in specialist publications.

4. I understand that my child's participation in this project is voluntary and I may choose to withdraw him / her at any time, without giving any reason.
5. My identity or that of my child will not be revealed in any discussion, description or scientific publication by the researcher.
6. I agree that my child is assessed and participates in this research project, and that the researcher can have access to my child's school file to obtain relevant information needed for the study.
7. Participation in this study will not result in any additional cost to myself.

I grant this as a voluntary contribution in the interest of training and knowledge.

Signed at…….on ……..2010

(place) (date)

Signature of Parent / Guardian……..

Signature of witness……..……..

Section B:

I do not agree for my child to participate in this research project.

Signature of Parent / Guardian:……..Date:……

Please return this consent form to your child's school.

ADDENDUM B

Biographical Questionnaire

A NEURODEVELOPMENTAL MOVEMENT PROGRAMME FOR 4 – 8YRS OLD HEARING IMPAIRED CHILDREN IN THE RURAL QWA-QWA REGION, SOUTH AFRICA

BIOGRAPHICAL INFORMATION QUESTIONNAIRE

Researcher: Mrs. Jó-Marié Bothma

P.O. Box 1088
HARRISMITH
9880
Tel: 072 725 1661 (office hours)

Dear Parent / Caregiver

September 2010

Confidential & Private

The following questions request information regarding you and your child's personal details. Please try to be as accurate as possible in your answers. All information will be treated with absolute confidentiality and anonymity. This questionnaire is to be completed by the parent / primary caregiver of the hearing-impaired child. ***Please complete this questionnaire by making a cross (X) in the appropriate space in the block that contains the information that is applicable to you and/or your child:***

PART A

This part contains questions about you, the parent (or primary caregiver) of the hearing-impaired child

1. Please indicate your ability to understand English:

Good	1
Average	2
Poor	3

2. Your birth date?

Date:	___dd___mm_____yyyy

3. What is your gender?

Male	1
Female	2

4. What is your home language?

English	1
Afrikaans	2
Sotho	3
Other	4
Specify:	

5. What is your marital status?

Married	1
Divorced	2
Separated	3
Single	4
Other Specify:	6

6. Indicate your relation to the hearing-impaired child:

Mother	1
Father	2
Other	3
Specify:	

7. Cultural group:

Black	1
Asian	2
White	3
Coloured	4
Other	5
Specify:	

8. Highest educational standard:

University attendance	1
Post-matric training (not university)	2
Matric (Grade 12)	3
Apprenticeship	4
Junior certificate (Grade 8 - 10)	5
Primary school (Grade 1 - 7)	6
No education	7
Specify any other	8

9. Current occupation:

Unemployed (Not working)	1
Employed: Please specify nature of your work_____	2
Self-employed: Please specify nature of your business_____	3
Other: Please specify	4

PART B

This part contains questions about the hearing-impaired child.

10. Hearing-impaired child's birth date:

Date:	___dd___mm_____yyyy

11. Hearing-impaired child's gender:

Male	1
Female	2

12. Hearing-impaired child's home language:

English	1
Afrikaans	2
South Sotho	3
Other	4
Specify:	

13. Hearing-impaired child's cultural group:

Black	1
Asian	2
White	3
Coloured	4
Other	5
Specify:	

14. Age at which child entered *school's name*:

Before age 2yrs	1
2yr – 3yr	2
3yr – 4yr	3
4yr – 5yr	4
5yr – 6yr	5
6yr – 7yr	6

PART C

This part contains questions about the nature of your child's hearing disability.

15. What was the cause of the hearing-impairment?

Unknown	1
Complications before pregnancy. Specify: _____	2
Complications during pregnancy. Specify: _____	3
Complications after pregnancy. Specify: _____	4
Other	5
Please specify:	

16. When was your child first diagnosed with a hearing problem?

0 – 1 yr	1
1yr – 2yr	2
2yr – 3yr	3
3yr – 4yr	4
4yr – 5yr	5
5yr- 6yr	6
6yr – 7yr	7

17. Co-morbid disorders (For example: visual problems, ADHD, Cerebral Palsy etc.)?

Please specify: _____ _____	1

18. Indicate whether applicable to your child:

Hearing aid	1
Cochlear implant	2
None	3
Other (specify):	4

19. My child communicate by means of:

Only sign language	1
Only verbal language	2
Only lip reading	3
Combination of above	4
My child cannot communicate at all	5

20. Where does your child stay during the school week?

With me at home	1
At the school hostel	2
Other	3
Specify:	

Parent / primary caregiver's name and surname:_____

Child's name and surname: _____

Kindly provide any further information or comments, which you consider to be important:

Thank you for completing the questionnaire. Please give this questionnaire to your child's class teacher or therapist at the School.

ADDENDUM C

Neurodevelopmental Evaluation Scale (NES)

Neurodevelopmental Evaluation Scale (NES)

Child's Name: **Date of assessment:**

The Vestibular System (Coordination & Balance)

1 ***Tandem Walk:***

	Forwards		***Backwards***	
Heel Toe Touch	yes	no	yes	no
Balance	good	poor	good	poor

0 = normal
1 = impaired
2 = unable

2 ***Manns Test***: (eyes closed)

0 = no difficulty (> 20s)
1 = mild difficulty (> 10 - 20s)
2 = moderate difficulty (5 - 10s)
3 = severe (<5s)
4 = unable to do single stance

3 ***Fog Walk:***

	Forwards		***Backwards***	
Upper limb extremities	yes	no	yes	no
Feet - (walk on sides?)	yes	no	yes	no
Balance	good	poor	good	poor

0 = normal
1 = impaired
2 = unable

4 ***Cross Pointing Walk:***

Midline cross -	yes	no
Smooth movement	yes	no
Balance	yes	no

0 = normal
1 = impaired
2 = unable

5 ***One Leg Stand:***

Preferred foot - (right / left)	Eyes Open -	_____ secs	Eyes closed -	_____ secs
Other foot - (right / left)	Eyes Open -	_____ secs	Eyes closed -	_____ secs

0 = no difficulty, >20s
1 = mild difficulty, 10 - 20s
2 = moderate difficulty, 5 - 10s
3 = severe, <5s
4 = unable to do single stance

The Visual System

6 ***Eye Tracking***

	Both eyes		***Left eye open***		***Right eye open***			
Any movement of head	yes	no	yes	no	yes	no		
Horizontal movement: jerky, watery, not smooth, no focus	yes	no	yes	no	yes	no		
Diagonal movement: jerky, watery, not smooth, no focus	yes	no	yes	no	yes	no	**/ 12**	Give 1 point for every "no"
Vertical movement: jerky, watery, not smooth, no focus	yes	no	yes	no	yes	no		

7 ***Convergence & Accommodation & Divergence***

Converge (yes / no) = both eyes move towards nose . . .

Accommodate (yes / no) = eyes stay on pencil @ 5cm . . **/ 3** Give 1 point for every "yes"

Divergence (yes/ no) = both eyes moves back to starting point

The Reflex System

8 ***ATNR:***

	LEFT	***RIGHT***
Schilder Test	0 = no response	0 = no response
Arms outstretched turn head	1 = slight movement of the arms	1 = in the direction the face is pointed
	2 = movement of the arms	2 = in the direction of the head (45 degrees & drop)
	3 = arm movement to 60 degrees	3 = or flexion of opposite side or drop
	4 = 90 rotation of the arms and/or loss	4 = of balance as a result of the head rotation / arms drop together or seperately

Final score = average of left & right

9 ***STNR:***

0 = no response

1 = tremor in one or both arms or slight hip movement

Over and under

2 = movement of the elbow on either side and /or definte movement in the hips / arching of the back

3 = bending of the arms on head flexion or movement of the bottom back on head extention

4 = bending of the arms to the floor, or movement of the bottom back onto the ankles (sitting "cat" position)

10 ***TLR:***

0 = no response

1 = slight alteration of balance as a result of head position or movement

Head Tilts

2 = distrubance of balance during test and/or alteration of muscle tone at the back of the knees

3 = near loss of balance, alteration of muscle tone and/or disorientation as a result of the test

.

4 = loss of balance and/or massive alteration of muscle tone in attempt to maintain balance (dizzy, nausea, panic)

ADDENDUM D

Programme Activity Monitoring

PhD Research: Neurodevelopmental movement sequence for *SCHOOL* | 2011

Name & Surname	Grade	Movement	Day
1	Grade Pre-R	Body Tucks	~~Mo: 1 2 3~~ ~~Tue: 1 2 3~~ We: ☑ 2 3 Thu: ☑ 2 3 Fri: ☑ 2 3
Name & Surname	**Grade**	**Movement**	**Day**
2	Grade Pre-R	Body Tucks	Mo: ☑ 2 3 Tue: ☑ 2 3 We: ☑ 2 3 Thu: ☑ 2 3 Fri: ☑ 2 3
Name & Surname	**Grade**	**Movement**	**Day**
3	Grade R	Body Tucks	Mo: 1 ☑ 3 Tue: 1 ☑ 3 We: 1 ☑ 3 Thu: 1 ☑ 3 Fri: 1 ☑ 3
Name & Surname	**Grade**	**Movement**	**Day**
4	Grade R	Body Tucks	Mo: ☑ 2 3 Tue: ☑ 2 3 We: 1 ☑ 3 Thu: 1 ☑ 3 Fri: 1 ☑ 3
Name & Surname	**Grade**	**Movement**	**Day**
5	Grade R	Body Tucks	~~Mo: 1 2 3~~ ~~Tue: 1 2 3~~ ~~We: 1 2 3~~ ~~Thu: 1 2 3~~ ~~Fri: 1 2 3~~
Name & Surname	**Grade**	**Movement**	**Day**
6	Grade 1	Body Tucks	Mo: 1 ☑ 3 Tue: 1 ☑ 3 We: 1 2 ☑ Thu: 1 ☑ 3 Fri: 1 ☑ 3
Name & Surname	**Grade**	**Movement**	**Day**
7	Grade 1	Body Tucks	Mo: 1 ☑ 3 Tue: 1 ☑ 3 We: 1 2 ☑ Thu: 1 ☑ 3 Fri: 1 ☑ 3
Name & Surname	Grade	Movement	Day
8	Grade 1	Body Tucks	Mo: 1 ☑ 3 Tue: 1 ☑ 3 We: 1 ☑ 3 Thu: 1 2 ☑ Fri: 1 2 ☑
Name & Surname	Grade	Movement	Day
9	Grade 1	Body Tucks	Mo: 1 2 ☑ Tue: 1 2 ☑ We: 1 2 ☑ Thu: 1 2 ☑ Fri: 1 2 ☑

Week 1: 31 January 2011 – 4 February 2011 (Key: 1 = unable / 2 = impaired / 3 = master)

ADDENDUM E

Consent Form from School Principal

A NEURODEVELOPMENTAL MOVEMENT PROGRAMME FOR 4 – 8YRS OLD HEARING IMPAIRED CHILDREN IN THE RURAL QWAQWA REGION, SOUTH AFRICA

CONSENT FORM

Researcher: Mrs. Jó-Marié Bothma
P.O. Box 1088
HARRISMITH
9880
Tel: 072 725 1661 (office hours)

July 2010

FOR ATTENTION: THE PRINCIPAL
School's Name

The Principal,

INFORMATIVE LETTER: RESEARCH RE NEURODEVELOPMENTAL MOVEMENT PROGRAMME

I am currently doing research for my Doctoral Degree in Psychology at the University of South Africa. The Hugenote College in support with UNISA approved the study: A research project evaluating a neurodevelopmental movement program by using the Revised Extended Griffiths Scales of Mental development (Griffiths), a neurodevelopmental evaluation scale, as well as the Child Behaviour Checklist (CBCL).

The primary objective of the study is to **implement, evaluate**, **and to design** guidelines for a **neurodevelopmental movement** programme for 4 – 8 yrs old hearing impaired children in a rural SA community. Hearing impaired children's overall development is influenced by their disability, and can negatively impact on their academic, social, emotional and perceptual functioning. More knowledge and research are needed in the rural South African context with regard to the selection and implementation of developmental movements, the influence of such movements on the development of children with hearing loss, as well as guidelines for when making use of such movement programmes to enhance development. If a **neurodevelopmental approach can enhance development in hearing impaired children** it can become a cost-effective and time-efficient intervention method to implement in a school curriculum.

This research project is aimed to **conduct research** on the effectiveness of the neurodevelopmental movement programme with a sample of **hearing impaired preschool, grade R and grade 1 learners**. By establishing the movement programme's effectiveness, the significance of such an approach as intervention method to stimulate a hearing impaired child's development will be determined. Written consent from the Free State Education Department has been requested and I am currently awaiting approval and permission from the department to continue with the study.

Should you give consent, the **hearing impaired preschool, grade R and grade 1 learners** would be requested to undergo pre-testing in January 2011, follow the movement programme during February to June 2011 and be reassessed (post tested) during the last week of the second term in 2011. These proposed dates might change, based on possible suggestions from the Department of Education's letter of approval. I will inform you accordingly of any changes. During the pre- and post-testing assessment which takes approximately one to two hours, children will be asked to complete a number of age appropriate tasks, such as building bricks, throwing a ball, drawing and naming pictures, as well as teachers will be requested to rate the child's behaviour. Thereafter, children will be randomly divided into either an experimental group or a comparison group. Those in the experimental group will partake in an 14-week neurodevelopmental movement program. During this program, which takes approximately 15 – 25 minutes per day, children will take part in activities such as rolling activities, and tummy crawling. These activities will be implemented in the mornings before official class starts and after breakfast. Those in the comparison group will be allowed to play freely or complete classwork under the watchful eye of a caring adult. After the completion of the 14-weeks program, all learners will be reassessed on the Griffiths and CBCL and neurodevelopmental evaluation scale. Those children in the comparison group will also then be given the opportunity to participate in the neurodevelopmental movement program, once the reassessment has taken place.

Be ensured that **complete anonymity** is assured and no information that will be used for research purposes will be able to be related back to the learners in their personal capacity.

It will be highly appreciated if **arrangements** with regard to a **second visit** from the researcher prior to the test date in order to create rapport and other logistics could be finalized during a meeting, during which I will be happy to answer any questions you may have. I will contact you regarding the arrangements.

Your assistance in the above regard will be highly appreciated! May this experience be of benefit to you as well as the learners. Should you at any time wish to contact me, I may be reached at 072 725 1661.

I thank you in advance for your co-operation.
Yours sincerely

Jó-Marié vdM Bothma
CLINICAL PSYCHOLOGIST

WRITTEN CONSENT FROM *SCHOOL'S NAME*

I hereby give permission for this research study to be conducted at Thiboloha School.

Printed name:_____Signature:_____

Capacity:_____

Date:_____Place:_____

ADDENDUM F

Approval from Education Department

education
Department of Education
FREE STATE PROVINCE

Enquiries: Malimane IM
Reference: 16/4/1/29-2010

Tel: 051 404 8662
Fax: 051 447 7318
E-mail: malimane@edu.fs.gov.za

2010 – 07 – 05

Mrs. JVDM BOTHMA
PIET RETIEF STREET 37
HARRISMITH

Dear Mrs. Bothma

REGISTRATION OF RESEARCH PROJECT

1. This letter is in reply to your application for the registration of your research project.

2. Research topic: **The Evaluation of a Neurodevelopmental Movement Programme for Hearing Impaired Children in a Rural Community.**

3 Your research project has been registered with the Free State Education Department.

4. Approval is granted under the following conditions:-

4.1 Learners participate voluntarily in the project.

4.2 The names of the participants and the schools involved remain confidential.

4.3 The questionnaires are completed and the interviews are conducted outside normal tuition time.

4.4 This letter is shown to all participating persons.

4.5 A bound copy of the report and a summary on a computer disc on this study is donated to the Free State Department of Education.

4.6 Findings and recommendations are presented to relevant officials in the Department.

5. The costs relating to all the conditions mentioned above are your own responsibility.

6. **You are requested to confirm acceptance of the above conditions in writing to:**

The Head: Education, for attention: DIRECTOR : QUALITY ASSURANCE
Room 401, Syfrets Building, Private Bag X20565, BLOEMFONTEIN, 9301

We wish you every success with your research.

Yours sincerely

FR SELLO
DIRECTOR: QUALITY ASSURANCE