Prevalence of Sensory Integrative Dysfunction in the Childhood Cancer Population

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DECLARATION

I certify that the dissertation hereby submitted for the M Med Sc degree at the University of the Free State is my independent effort and has not been previously submitted for a degree at another University/ Faculty.

I furthermore waive copyright of the dissertation in favour of the University of the Free State.

Signed:

Ms Gina Rencken (nee Loudon)

31 May 2011

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CLARIFICATION OF CONCEPTS

Sensory integration: the neurological process that organises sensation from one's own body and from the environment and makes it possible to use the body effectively within the environment (Bundy, Lane & Murray, 2002, p4, 103).

Sensory integrative dysfunction: difficulty in the way the brain processes, organises and uses sensory information, causing a person to have problems interacting effectively in the everyday environment. A dysfunction may cause difficulty in ones movement, emotions, attention, relationships or adaptive responses (Abraham 2002, p122).

Vestibular sense: this is the balance and movement sense. It is the sensory system that responds to the pull of gravity, providing information about the head position in relation to the surface of the earth, and coordinating movements of the eyes, head and body that affect equilibrium, muscle tone, vision, hearing and emotional security. Receptors are in the inner ear (Ayres 2005 IN Kranowitz, C A, 2005 p 115).

Postural adjustments: automatic movements in the child's trunk and limbs, allowing him to maintain his body position and feel secure while moving through space or using the muscles necessary for a specific function (Kranowitz, 2005)..

Visual system: the ability of the child to use his eyes to identify sights, understand what he sees and prepare for a response (Kranowitz, 2005, p155, Bundy, Lane & Murray, 2002, p61).

Tactile system: the sensory system that receives sensations of pressure, vibration, movement, temperature and pain, primarily through receptors in the skin and hair. Protective receptors respond to light or unexpected touch and help a person avoid bodily harm; discriminative receptors provide information about the tactile qualities of the object or person being touched (Abraham, 2002, p122; Bundy et al, 2002, p 480).

Motor planning: the ability to interact successfully with the physical environment; to ideate, plan, organise and carry out a sequence of unfamiliar actions and to do what one needs to do (Bundy et al, 2002, p77).

Gross motor: movement of the large muscles of the trunk, arms and legs in the performance of tasks (Abraham, 2002, p124).

Fine motor: movement of the small muscles of the fingers, toes, eyes and tongue(Abraham, 2002, p124).

Visual-motor skills: movements based on the discrimination of visual information (Kranowitz, 2005).

Visual-spatial skills: awareness of the spatial orientation of objects relative to the self and other persons (Kranowitz, 2005).

DESIGN COPYING ERRORS (Ayres, 2004, p45)

Additions are extra lines, or "grossly inappropriate, non normal, deliberate, and illogical additions to a figure". They may be added for different reasons, including a random, disorganised attempt at replicating the figure, a perseveration or an attempt at embellishment. Excessive redrawing of a line back on itself is considered an addition, as this shows perseverative behaviour.

Boundary refers to the printed block in which the child has to replicate the drawing on the test booklet. This is scored as a "should not have" parameter if the child uses this printed line as part of the drawing; his drawing touches the boundary, or if part of the figure is drawn outside the boundary.

Jogs or Ears are "a definite identifiable quality of irregularity at a corner or in a line". These are purposefully produced due to confusion if the child in planning g and executing the direction of drawing, when he is trying to make a corner with one continuous line.

Reversal occurs when details on one side of the stimulus figure are drawn on the opposite side in the child's reproduction, with the child's drawing being a mirror image of the stimulus.

Right to Left is when the child's drawing is started on the right, and his lines continued to the left.

Inversion is the reproduction of a figure which is upside down.

Segmentation is when a drawing is not done in a logical sequence, indicating that the child visually perceives the stimulus figure in a way which is different to his peers. A drawing may be perceived as separate parts joined together instead of as a unit, and the child's approach to copying it will reflect this perception. It gives an indication of the child's spatial awareness

CONSTRUCTIONAL PRAXIS PARAMETERS (Ayres, 2004, p70)

1. **Displacement of 1 through 2½ cm.** The block is placed in the correct location and with the correct orientation, but displaced 1 to 2½ cm in relation to the model.
2. **Displacement more than 2½ cm.** The block is placed in the correct location and with the correct orientation, but displaced 1 to 2½ cm in relation to the model.
3. **Rotation more than 15 degrees.** The block is rotated around a vertical axis by more than 15^0, but not sufficiently so to have it considered a right to left or front to back (parameter 4) error.
4. **Upside down, right for left, front for back, or end for end.** Rotation of the block around a vertical axis so that it is positioned upside down, reversed or vertical instead of horizontal, despite resting on the correct blocks and in the correct position.
5. **Placement incorrect but logical.** A placement of a block which makes a meaningful and logical contribution to the model, but is incorrect in its choice, such as substitution with a block of a similar shape.
6. **Gross Mislocation.** Placement of a block in the structure without a logical resemblance to the block's position in the model. Blocks randomly placed in the model or pushed up against the model.
7. **Omission.** Any blocks not included in the model when the child has indicated that they have completed the task.
8. **Ok.** Placement of the block in the correct position with the correct orientation, with an error not scored on any previous parameter, if slight error is present.

CHAPTER 1

-INTRODUCTION AND ORIENTATION TO RESEARCH-

For the purposes of this study, the researcher will be referred to in the feminine form as she/her and research subjects of both genders will be referred to in the masculine form, as he/him.

1.1 INTRODUCTION

With advances in modern medicine and improved protocols for treating children with childhood cancer, the survival rate has dramatically increased over the past three decades (Moore, 2005, p51-63; Condren, Lubsch & Vats, 2005, p32). There has been a shift in the focus of paediatric oncologists and other members of the multidisciplinary team towards the identification and management of late effects of childhood cancer and the treatment thereof and the effect of these on the child's quality of life as they enter adolescence and adulthood. Many late effects of treatment in various systems and body organs have been identified; these include visual deficits, hearing loss, deficits in learning, memory and attention, deficits in executive function and poor eye hand coordination (Texas Children's Cancer Center). The researcher had noted occurrences of possible sensory integrative disorders characterised by bilateral integration and sequencing difficulties, vestibular dysfunction and poor modulation, noted in children having difficulty coordinating their body movements during playing games, and becoming motion sick more rapidly than typically developing children occurring in some of the children who were undergoing treatment for childhood cancer and were receiving occupational therapy; however no literature could be found to explain or substantiate these findings. In this study, the researcher herself strives to determine the prevalence of sensory integrative disorders (dysfunction) among this population.

The results of the research project will indicate whether or not there is a reportable prevalence of sensory integrative disorders among members of the childhood cancer population. Based on these findings, therapeutic intervention strategies and referrals to appropriate centres can be implemented in order to provide these children with the intervention and support they require which will improve their participation in daily occupations, quality of life and hopefully make them more functional adolescents and adults.

1.2 PROBLEM STATEMENT

Uncertainty exists regarding the prevalence of sensory integrative disorders among children diagnosed with and undergoing treatment for childhood cancer. While guidelines for the specific areas of assessment in the child with cancer includes a sensorimotor evaluation as well as assessment of the core skills of tactile, vestibular and proprioceptive function, no literature describing such studies could be found (Cooper, 2007,p117). The study proposes to determine the prevalence of sensory integrative disorders among these children undergoing treatment at State funded Paediatric Oncology Units in Gauteng and the Free State. The prevalence of sensory integrative disorders between children diagnosed with different types of childhood cancer remains unknown.

Current protocols for the treatment of various types of childhood cancer include surgery, chemotherapy and radiation. Certain of the chemotherapeutic agents are known to be cytotoxic and radiation is known to cause damage to white matter. Neuropsychological and neurocognitive effects, such as poor attention and memory, poor visual constructional ability, decreased IQ, distractibility, impulsivity and poor mathematics and reading skills, of these treatment methods have been documented (Moore, 2005,p51-63; Texas Children's Cancer Center). Long term effects of childhood cancer have been noted in many body systems, including ophthalmologic and auditory. These include, but are not limited to decreased visual acuity, poor school performance, vertigo, tinnitus, learning difficulties, poor executive functioning, impulsivity, distractibility, and poor eye-hand coordination (Texas Children's Cancer Center).

1.3 PRIMARY GOAL/AIM AND OBJECTIVES

The primary aim of the study is to determine if there is a noteworthy prevalence of sensory integrative disorders among children diagnosed with and receiving treatment for childhood cancer. The study further aims to gain a greater understanding of the types of dysfunction experienced by these children.

1.4 SCOPE OF THE STUDY

The study population comprised of children receiving treatment for childhood cancer at three paediatric oncology units in South Africa: Johannesburg Hospital (Charlotte Maxeke Johannesburg Academic Hospital), Universitas Hospital and Kalafong Hospital. The members of the sample group were considered to be a fair representation of the larger population of childhood cancer sufferers who were receiving treatment at one of the nine state funded paediatric oncology units in South Africa. The study population was made up or 39 children with cancer, who were currently undergoing treatment for their disease.

1.5 METHODOLOGY

A non-experimental, descriptive, cross-sectional, quantitative research design was followed (Bailey, Diana M, 1997, p 49; Katzenellenbogen, JM, Joubert, J, Abdool Karim, S, 2005, p67, 68). Thirty nine children were chosen by judgmental sampling after meeting the pre-determined inclusion and exclusion criteria. The three hospitals in the study were chosen as two where the researcher worked as an Occupational Therapist during the course of the study (Charlotte Maxeke Johannesburg Academic Hospital and Kalafong Hospital) and the academic hospital affiliated with the University of the Free State where the Masters degree was being pursued (Universitas Hospital). Guidelines for administration of the Sensory Integration and Praxis Tests (SIPT) were followed as stipulated by the developers of the test , to ensure accurate results were obtained (Ayres, 2004, p11-107). Data was collected by the researcher and an assistant, with the help of a translator if deemed necessary. Information collected on each child included their SIPT results, demographics, diagnosis, treatment received, administration method of treatment and observations made during testing. An additional tool, the Sensory Profile Caregiver Questionnaire was administered in 14 of the cases. Data was analysed and described using descriptive statistics, to investigate the prevalence of sensory integrative disorders in the study population.

1.6 IMPORTANCE AND VALUE OF THE STUDY

The importance and value of the study for medical professionals, allied health professionals, parents and children lies in the identification of a long term effect or side effect on childhood cancer and its treatment. Sensory integrative disorders can have an impact on play, academic functioning and social relationships if left unidentified and untreated. By highlighting the prevalence of sensory integrative disorders in this population, and discussing the patterns of dysfunction occurring in these children, focused, specific treatment intervention from a sensory integrative perspective can be started as soon as the child is stable and can participate in therapy. This early identification and intervention can have a significant positive effect on aspects such as the child's play, academic functioning and social-emotional state. Occupational therapy is and would be a valuable part of the multidisciplinary approach to childhood cancer treatment to address the many areas affected by the disease, hospitalization and effects of treatment. The value of this study in Occupational Therapy would be that it would be the start to designing efficient, cost effective and goal directed protocols for treating these children to remediate areas of difficulty and minimize long term effects of treatment in physical, academic, emotional and behavioral areas.

1.7 ETHICAL CONSIDERATIONS

Ethical approval was obtained from the Ethics committee of the Faculty of Health Sciences of the University of the Free State before commencement of the study, and for children investigated at Universitas Hospital **(Appendix 1).** Ethical approval was also obtained from all institutions from which the patient population was gathered. Approval was gained from the University of Witwatersrand for the children investigated at Johannesburg Hospital (ethics approval for protocol M071016), **(Appendix 2)**, from the University of Pretoria for Kalafong Hospital **(Appendix 3).** The participant or institutions were not put at risk by participation in this study and there is was no risk to the health of the individual.

Results of the study will be published in a research report in an accredited journal and may be presented at appropriate congresses in South Africa and abroad.

Participation in the study did not influence the disease treatment in any way and normal, standard protocols had been followed for the treatment of the cancer. If the child was determined to have sensory integrative dysfunction after assessment, it was reported to the paediatric occupational therapist at the relevant hospital and treatment was recommended to commence as soon as the child is able to participate.

The parents or legal guardians of the child were informed of the purpose of the study and what the testing entailed. They were required to sign an informed consent form, thus allowing their child to participate in the study. The child's verbal assent to testing was required. If he declined to participate, this decision was respected and he was excluded from the study. If parents did not wish to take part, this decision was respected and their child was excluded from the study. Their child still received therapeutic intervention where it was indicated.

Parents were informed of their child's performance in the testing and any intervention strategies that were deemed appropriate were discussed and planned in consultation with them.

Confidentiality was maintained by assigning each participant a unique code, which was used on the data sheet instead of his/ her name.

1.8 CHAPTER OUTLINES

1.8.1 Chapter 2 : Literature Review

The literature review provides some detail on previous research and findings into the late effects of childhood cancer treatment, specifically the neurocognitive and neurobehavioral effects. A brief explanation of sensory integration is given, and the researcher attempt to show links between neurocognitive side effects, learning difficulties and sensory integration theory. Some aspects of the child's experience of the hospital setting and the trauma of the diagnosis and treatment is discussed in the light of institutionalization and trauma experiences on sensory integration in children.

1.8.2 Chapter 3: Research Methodology

In this chapter the research methodology is discussed in detail. Information on the study design, sampling, test instruments, data collection, reliability and validity, and analysis of the data is discussed.

1.8.3 Chapter 4: Results

Descriptive statistics are used to give meaning to the results obtained.

1.8.4 Chapter 5: Discussion

The results of interest to the study are discussed here. Possible reasons for the results obtained are explored and discussed.

1.8.5 Chapter 6: Conclusion and Recommendations

The results supporting and disputing the research hypothesis are compared and the research question is answered. A critical evaluation of the research process reveals recommendations for changes to similar research studies and poses some questions for the future. Recommendations regarding the care of children with cancer in state funded paediatric oncology units are made.

1.9 SUMMARY

The aim of the research project, value of the study and research process followed was described in this chapter.

CHAPTER 2

-LITERATURE REVIEW-

2.1 INTRODUCTION

The purpose of the study was to determine the prevalence of sensory integrative difficulties among the childhood cancer population. A review of existing literature on sensory integration and literature on childhood cancer is presented in this chapter. The development of the theory and current beliefs based on sensory integration theory, assessment, types of dysfunction and effect on play is explored. The side effects of medication used in childhood cancer treatment, especially reported late effects are examined. Literature surrounding neurobiology, specifically in the light of sensory integration, learning and neurocognitive side effects of cancer treatment is included. The diagnosis of and treatment for childhood cancer is a traumatic experience, with a very real threat of death despite advances in treatment. Treatment spans many months, with children often staying in hospitals or in socially isolated situations for long periods. Literature on the effect of a trauma experience on the child and the effect of institutionalisation is also reported to gain a deeper understanding of the world of the child and the prevalence and possibly causative factors of a sensory integrative disorder.

2.2 SENSORY INTEGRATION

2.2.1 Introduction to Sensory Integration

Florence Clark stated in her foreword to the book ‘Understanding the Nature of Sensory Integration with Diverse Population’ (Smith Roley, Blanche & Schaaf, 2001, p, XV)”one of the key barriers to occupational justice for children, as well as for some adults, is sensory integration dysfunction”.

Dr Jean Ayres defined sensory integration as “the neurological process that organises sensation from one’s own body and from the environment and makes it possible to use the body effectively within the environment” (IN Bundy, Lane & Murray, 2002, p4). Sensory integration theory is a theory of brain-behaviour relationships which is used to explain why individuals behave in a certain way, and this enables therapists to assess and then plan intervention strategies to remediate specific difficulties and predict how the individual’s behaviour will change as a result of the intervention. Sensory Integration development unfolds in a predictable pattern as the central nervous system develops across the lifespan. Theory assumes that genetic coding plays a role in the maturation process of the brain and in the development of sensory integration but it is also dependent on the interaction of an individual within a certain context (physical and social environment) (Smith Roley, Blanche & Schaaf, 2001, p12). The development of sensory integration is observable in the child’s ability to maintain a calm-alert state, develop and master new skills, interact with others and participate in everyday activities (Parham & Fazio, 2008, p263) The development of typical sensory integration and thus normal functioning is dependent on the child’s ability to register sensory information, then modulate the information in order to obtain an optimal state of arousal that is necessary for the task at hand and then discrimination of information needs to take place in order for skilled functions to be executed (Smith Roley, Blanche & Schaaf, 2001, p14).

Sensory integrative dysfunction occurs in individuals who have a diminished ability to process sensation from the body and the environment, and thus experience difficulty in generating appropriate actions. The inappropriate actions and behaviours exhibited by these individuals interfere with learning and behaviour. According to Spitzer and Smith Roley (IN Smith Roley, Blanche & Schaaf, 2001, p14) "research has confirmed the relationship to functioning in various daily occupations". Correlations have been made between the role of sensory integration dysfunction and reading and arithmetic achievements, tactile defensiveness has showed to have an effect on inflexible- and repetitive behaviours and sensory defensiveness has been linked to emotions such as frustration, annoyance and fear.

Sensory integration intervention provides in a child's sensory needs and will assist the child in making adaptive and organised responses in the daily activities in which he has to perform (Smith Roley, Blanche & Schaaf, 2001, p17). Intervention programmes for sensory integrative dysfunction are guided by meaningful activity and enhanced sensation leading to adaptive interaction, a purposeful and goal directed action which enables an individual to overcome a challenge and learn a new skill. This is believed to enhance learning and behaviour due to an increased ability to process sensation and to ultimately support the child to participate successfully in occupations (Bundy, Lane & Murray, 2002, p5; White, Mulligan, Merrill & Wright, 2007, p154-159).

The human brain has developed most of its neurons by six months gestation. The brain undergoes a dynamic stage of development during childhood, with the volume of certain types of brain tissue increasing and others decreasing. The volume of grey matter increases rapidly and peaks at the age of four years. During this period, neurons grow, dendritic arborisation increases and new synapses form. After this, apoptosis takes place and grey matter decreases. This is a programmed process of cell death, which eliminates unnecessary neurons and synaptic connections and results in a more efficient brain (Moore, 2005, p51-63). Sensory integration theory is based partly on the assumption that the central nervous system is plastic and brain structures have the ability to change (Bundy, *et al*, 2002, p10; Case Smith & O Brien, 2010, p327). Myelination begins during the third or fourth month of gestation and continues to increase in volume until the age of 20 years, with the axons of the association areas and cortical projection areas becoming fully myelinated in the adult years.

The tactile sense is already functioning in-utero and already plays a vital role in survival during the first few weeks of life (Ayres, 1977 p 61; 2005, p16). Tactile receptors are especially rich in the skin and mouth. The influences from this sense shape how we perceive our world and have a pervasive effect on our social and emotional development. The tactile system responds to stimuli in one of two ways, discriminatory or protective. Discriminatory responses provide us with information regarding where and how we are touched, the qualities of objects based on their texture, temperature, density and spatial characteristics. These are more complex responses, and involve processing and interpretation of information in the sensory cortex. Protective responses are automatic and activate a fright, flight or fight response in reaction to information that is perceived to be dangerous or threatening (Ayres, 2005, p109; Murray-Slutsky and Paris, 2005, p13). Ayres has already stated in one of her first publications that the tactile system is a sensory system that plays a critical role throughout human life and "that it is especially involved in the ongoing process contributing to perception of other types of sensation" (Ayres, 1977, p61).

The proprioceptive sense has receptors in joints and muscles and provides us with information about the position of our body and state of tension in our muscles. It forms an internal map of our body, its position and action, and provides information about the relation of our body to the external environment, the amount of pressure we are exerting on an object, the external resistance to our movement and the force or pressure required to accurately perform a task. Ayres (1977, p69) originally stated that the proprioceptive system plays an important role in the sensory integrative process. She not only described the proprioceptive system as a calming and organising system that can be used to effectively modulate arousal levels and regulate over responsiveness to other sensations like movement and touch but she also acknowledged the role that this system plays in visual form and space perception (Ayres, 2005, p119).

The vestibular sense detects movement, specifically of our head in relation to the earth and gravity. The force of gravity is received by receptors within the labyrinth structure located in the inner ear. Any change that occurs in the pull of gravity is received by the gravity receptors, and will change the information in the vestibular system (Ayres, 2005, p41, 42). The semicircular canals (also located in the inner ear) provide us with information on the speed and direction of movement of the head. When the direction or speed of head movement changes the receptors in the semicircular canals will detect it and change the information within the vestibular system (Ayres, 2005, p42). The vestibular system is already well developed by five months in-utero and plays an important integrating role throughout life. Vestibular information also has a direct influence on our arousal levels, and movement can be calming, alerting or possibly disorganising, depending on the type of movement and how it is processed. Generally slow, linear and rhythmic movements are calming, while angular, fast and spinning movements tend to be arousing (Murray-Slutsky and Paris, 2005; p14, Ayres, 2005, p84). Information from our vestibular system provides us with a reference point from which we can make sense of visual information, influence muscle tone to maintain postures against gravity, maintain balance, develop a concept of spatial relations and emotional stability (Ayres, 2005, p63-69).

Sensory integration involves the senses working together to enable us to form a picture of ourselves relative to the environment and objects in it. Ayres has already written in her early publications about the importance of "intermodality associations, a process of particular academic importance" (Ayres, 1977, p28). She also stated that "intermodality associations occur at all levels of the brain" and that higher levels of brain function are dependent upon that what occurs at lower brain levels (Ayres, 1977, p28).

Murray-Slutsky and Paris (2005, p14, 15) describes in a very practical way what Ayres had explained as "intermodality association" in her early literature: Tactile information integrates with visual perception as children explore an object through touch, feeling it and mouthing it, and connecting this to its visual image. These concepts become important in object recognition, spatial relations, reading and other academic skills in later childhood. Tactile information also combines with proprioceptive information to enable children to understand or perceive and adapt their movements in relation to objects. This is the beginning of the development of stereognosis, which allows a child to develop skills such as locating a pencil in a chair bag at school, locate a soft toy in bed at night or reach into a pocket to pull out coins to purchase sweets at the tuckshop. The ability to grade enforced pressure, which is achieved when these two systems effectively integrate, enables the child to write or draw without breaking pencil nibs, to play without breaking toys and to form words in speech. The vestibular, tactile and proprioceptive senses integrate to provide children with an accurate internal map of their body and internal knowledge of their movement through space. This allows them to play on jungle gyms, participate in team sports and enjoy activities like dancing, gymnastics, martial arts and individual sports.

Sensory integration theory of Ayres assumes that there is plasticity within the central nervous system, implicating that the brain structures have an ability to change. Intervention derived from this theory is hypothesised to effect changes in the brain because of this plasticity (Bundy *et al*, 2002, p10, 11). The structural and behavioural plasticity of the young brain, especially in the three to seven year old child is particularly emphasised, although research has shown that plasticity continues into adulthood (Case-Smith & O'Brien, 2010, p327). The theory also assumes that sensory integration develops, with behaviours present at each stage in the developmental sequence, providing the basis for the development of more complex behaviours. A further assumption of the theory is that the brain functions as an integrated whole. Ayres believed that higher-order integrative functions evolved from and are dependent on the integration of "lower order structures" and sensorimotor experiences (Bundy *et al*, 2002, p11; Ayres, 1977, p9, 10, 13, 14). Higher order (cortical) centres of the brain are viewed as being responsible for abstraction, perception, reasoning, language and learning. Sensory integration was viewed as occurring mainly within lower (sub cortical) centres. Lower structures of the brain are believed to develop and mature before higher-level structures. The development of optimal functioning in higher areas is partly dependant on the development and optimal functioning of the lower order structures. Intact systems, both cortical and subcortical, contribute to sensory integration. Sensory integration theory assumes that adaptive interactions are critical to sensory integration. An adaptive interaction occurs when an individual interacts with his environment and meets a challenge or learns something new. Adaptive interactions promote sensory integration and the ability to contribute to an adaptive interaction, reflects sensory integration. We learn from past experience only when we know our actions are successful. Schaaf and Smith Roley (2006, p 2) states that Ayres "hypothesized that by providing enriched sensory opportunities processed at the level of the brain stem, and by stimulating the child's motivation via the limbic system with 'the just-right' sensory and motor challenges, the child would make generalizable higher level adaptive responses and be more willing to tackle challenges in everyday life". The final assumption of the theory is then that people have an inner drive to develop sensory integration through participation in sensorimotor activities (Bundy *et al*, 2002, p12).

2.2.2 Assessment of Sensory Integration

Assessment of sensory integration is important if one would like to gain a deeper understanding of reasons for particular behaviour manifest by a child, and a deeper understanding of barriers to play and learning**.** It also assists in planning intervention strategies that would be most effective for a child in overcoming these barriers and enabling them to reach their potential.

Sensory integration can be assessed in many manners, including parent questionnaires, self report questionnaires, clinical observations in various settings and standardised tests. Initial indication that a child may have a sensory integrative dysfunction is based on observations of the child in play, activities of daily living, interactions with others and school work. Children with sensory integrative dysfunction may be withdrawn, isolate themselves from social situations, become anxious in new surroundings, be irritated by and particularly sensitive to textures of food and clothing, sounds, smells and lighting. They may also be boisterous, hyperactive and loud, controlling games and social situations (Murray-Slutsky and Paris, 2005, p16).

The assessment instruments that will be used in this research will now be discussed according to available literature

2.2.2.1 Sensory Integration and Praxis Tests

The Sensory Integration and Praxis Tests (SIPT) is considered the gold standard for assessment of children aged 4 years to 8 years 11 months, if one wishes to gain a better understanding of children with irregularities in learning and behaviour. The SIPT measures various practic skills, the sensory processing ability of the tactile, vestibular, proprioceptive, visual and kinaesthetic systems and behavioural manifestations of disorders in sensory processing from these systems (Ayres, 2004, p1).

The SIPT comprises of 17 subtests. These 17 tests can be broadly categorised into four groups: tests of form and space perception, tests of vestibular and somatic sensory processing, test of praxis and tests of bilateral integration and sequencing. These groups are not mutually exclusive (Ayres, 2004, p2-8). The SIPT was standardised with a normative sample of 1997 American children aged 4 years to 8 years 11 months. This sample was made up of children from rural and urbanised areas, and represented the ethnic diversity of the American population at the time of standardisation (Bodison & Mailloux, 2006, CE-2). **Table 2.1** provides a summary of the test items, materials needed, expected reactions from the child and skills assessed by each subtest.

The overall pattern of SIPT scores achieved, once the total test has been administered, can be compared to patterns of six predetermined clusters (based on a cluster analysis that was done on a heterogeneous group of children inclusive of children that experienced clinically significant problems and children without problems) (Ayres, 2004, p179, 178). In order to get a complete picture of the child, the information from the pattern of scores should be interpreted with information such as the child's history, knowledge of his intellectual capacity, development, academic achievement, psychiatric and medical diagnoses and clinical observations of ocular responses, postural responses, response to tactile stimuli and gravitational security. The clusters have been named as follows:
Group 1: Low average Bilateral Integration and Sequencing
Group 2: Generalised Sensory Integrative Dysfunction
Group 3: Visuo and Somatodyspraxia
Group 4: Low Average Sensory Integration and Praxis
Group 5: Dyspraxia on Verbal command
Group 6: High Average Sensory Integration and Praxis

Only groups, 2, 3 and 5 are considered to be dysfunctional. Groups 4 and 6 include children with average and high average functioning
A Bilateral Integration and Sequencing Deficit (group 1) is only considered to be present when major characteristics of this deficit are present and they cannot be accounted for by the presence of any other condition (Ayres, 2004, p131).

Further research has been done on factor and cluster analysis of the SIPT. Shelley Mulligan did a cluster analysis of a large group of children who had been tested on the SIPT. These results showed five prototypic groups of disorders, classified according to the type of disorder as well as the severity of the disorder. These are: Average Sensory Integration and Praxis, Moderate Sensory Integration Dysfunction, Severe Sensory Integration Dysfunction and Dyspraxia, Dyspraxia and Low Average Bilateral Integration and Sequencing (Mulligan, 2000 IN Mailloux, Mulligan, Blanche, Cermak & Coleman, 2011, p144).

Table 2.1 SIPT SUBTESTS AND WHAT THEY MEASURE

Subtest name	*Materials*	*Expected actions of child*	*Skills assessed*
Space Visualisation (SV)	One form board with egg shaped cut-out, one form board with diamond shaped cut-out. Four egg shaped blocks. Four diamond shaped blocks. Small pegs.	Child identifies which block, from a choice of two, will fit into the form board in which the examiner has placed a small peg. The peg aligns with a hole in the block. Items increase in complexity as the subtest progresses.	Mental manipulation of objects in space. Response time. Tendency to cross the body midline. Preferred hand use in a task.
Figure Ground Perception (FG)	Test booklet with 16 pages of line drawings (embedded figures and singular figures.)	Child looks at the test plate which contains embedded line drawings of familiar and unfamiliar objects. He then identifies the three embedded pictures from a series of six line drawings on a separate page.	Ability to identify a foreground figure from a rival background.
Standing and Walking Balance (SWB)	Wooden dowel.	Child statically and dynamically balances in a variety of postures and movements with eyes open and closed.	Ability to maintain static balance with eyes open or closed. Ability to maintain dynamic balance with eyes open or closed.
Design Copying (DC)	Two pencils. DC test booklet with shapes to copy. DC examiner booklet to replicate child's drawings.	Child copies figures in test booklet using dots to guide him first, them copying in open boxes.	Ability to copy what is being visually perceived. Ability to spatially organise work in a two-dimensional area. Identify presence of atypical approaches to copying figures (jogs, segmentations, reversals, additions, inversions).
Postural Praxis (PPr)	None	Child imitates all of 17 postures that the examiner assumes.	Ability to rely on tactile and proprioceptive awareness to motor plan how to assume and

			imitate the posture.
Subtest name	***Materials***	***Expected actions of child***	***Skills assessed***
Bilateral Motor Coordination (BMC)	None	Child replicates reciprocal, smoothly executed movements of examiners hands and feet.	Ability to rely on vestibular and proprioceptive processing to time and sequence hand and foot movements in smooth, coordinated fashion. Ability to use the two sides of the body together.
Praxis on Verbal Command (PrVC)	Child-sized chair.	Child follows verbal instruction given by examiner to assume unusual postures in sitting and standing.	Ability to follow verbal directions. Ability to plan movements based on verbal instructions. Ability to rely on tactile and proprioceptive awareness to motor plan how to assume an unusual posture without a visual model.
Constructional Praxis (CPr)	Two sets of building blocks.	Part 1: child replicates a simple structure built in phases by the examiner. Part 2: child replicates complex model using the preassembled structure as a visual guide.	Ability to relate objects to each other and motor plan construction in a three dimensional space. Identifies existence of atypical constructional approaches (incorrectly placed and omitted blocks).
Postrotary Nystagmus (PRN)	Nystagmus board.	Child sits on the board while it is rotated 10 times. After the board is abruptly stopped, nystagmus duration is observed.	One aspect of CNS processing of vestibular information is assessed.
Motor Accuracy (MAc)	MAc test booklet.	Child draws a red line on top of a	Visuomotor coordination.

	Two red pens.	heavy, pre-printed black line, attempting to stay on it at all times.	Ability to cross the midline.
Subtest name	***Materials***	***Expected actions of child***	***Skills assessed***
Sequencing Praxis (SPr)	None	Accurate imitation of a series of hand movements performed by the examiner, including tapping the table, tapping the other hand or tapping the head.	Ability to rely on tactile processing to plan movement of arms and hands in space. Ability to coordinate two sides of the body. Visual, auditory and kinaesthetic memory.
Oral Praxis (OPr)	None	Child imitates examiners movements of tongue, teeth, lips, cheeks and jaw.	Ability to rely on tactile and proprioceptive awareness to plan movements of tongue, teeth, lips, cheeks and jaw.
Manual Form Perception (MFP)	Plastic geometric shapes, stimulus card, shield (to occlude vision).	Part 1: accurate identification of shape on stimulus card with one hand while shape is being felt behind the shield with the other. Part 2: use of one hand to feel a geometric shape while the other hand feels a selection of geometric shapes to find a matching one.	Ability to combine tactile and kinaesthetic information. Ability to sequentially analyse what is being felt in order to form an understanding of the next steps. Ability to coordinate tactile and kinaesthetic information from both sides of the body.
Kinesthesia (KIN)	KIN test booklet. Shield.	The examiner moves the child's pointed finger from one location to another, and back again. The child has to replicate the first movement.	Ability to rely on tactile and proprioceptive awareness to accurately move arms and hands in space. Ability to make appropriate postural adjustments to move arms freely in isolation from the

trunk.

Subtest name	***Materials***	***Expected actions of child***	***Skills assessed***
Finger Identification (FI)	Shield.	Accurate indication of finger touched by examiner while vision was occluded.	Ability to rely on tactile and proprioceptive awareness to identify which finger(s) were touched. Ability to tolerate light touch from another person.
Graphesthesia (GRA)	Shield.	Replication of simple design drawn on the child's hand whilst vision was occluded.	Ability to rely on tactile and proprioceptive awareness to discriminate how the hands are being touched. Spatial and temporal analysis of passively received stimuli to create a visual image of the line drawing of perceived touch. Ability to produce a motor response replicating the perceived pattern from this touch. Ability to tolerate light touch from another person.
Localisation of Tactile Stimuli (LTS)	Shield. Marking pen.	Accurate indication of light touch made by examiner on the child's arm or hand.	Ability to rely on tactile and proprioceptive awareness to discriminate location of touch on the hands and arms. Ability to tolerate light touch from another person.

Bodison & Mailloux, 2006, CE-4 – CE-7
Ayres, 2004, p2-8

2.2.2.2 The Sensory Profile

The Sensory Profile, developed by Winnie Dunn and published in 1999 is a parent or caregiver questionnaire, using a likert scale where parents or caregivers are requested to rate the child's behavioural response to sensory events in everyday life. It can be used as part of a comprehensive evaluation and adds value to the assessment of sensory integration. The questionnaire contains items which can be roughly categorised into three sections, sensory processing, modulation and behaviour and emotional regulation.

Assessment of sensory integration should be done by an adequately qualified professional who has knowledge in normal and abnormal child development and behaviour and knowledge of sensory integration theory. The results from the assessment assist in developing a complete picture of the child strengths and weaknesses regarding sensory integration functions that supports occupational performance components and occupational performance areas, highlighting areas of difficulty and the reasons underlying these and assist in appropriate intervention planning to enable these children to overcome these barriers and lead lives as close to normal as possible (Ayres 2004, p1-2).

2.2.3 Sensory Integrative Dysfunction

Ayres has performed numerous factor analytic studies between 1972 and 1989 that not only validated sensory integration theory but also identified patterns of sensory integration dysfunctions (Schaaf, Schoen, Smith Roley, Lane, Koomar & May-Benson IN Kramer & Hinojosa, 2010, p 111). Factor analytic studies based on the original work of Ayres are still continuing.

Children with sensory integrative dysfunction experience difficulties to organise sensory information from their bodies and from the environment. It is a breakdown in the central processing of normal neurological processes. These dysfunctions may present themselves in cognitive, motor, social, emotional, behavioural, speech, language or attention disorders. The child is unable to respond to sensory information appropriately and plan and organise accurately what he needs to do in his school, social or home environment. These children typically present with delays in speech, language or motor skills, difficulty with transitions from one situation to another, inconsistencies in task performance, a high degree of distractibility, impulsivity, an inability to unwind or calm themselves, over or under sensitivity to touch, movement, sight or sound, physical clumsiness, poor self esteem, social, emotional and behavioural difficulties and an unusually high or low activity level (Ayres, 2005, p51-53; Abraham, 2002, p6; Murray-Slutsky & Paris, 2005, p15). Delays in academic achievement are a prominent and debilitating outcome of sensory integrative disorder in children. Children with sensory integrative dysfunction often show little motivation to be active participants at an optimal level of arousal or activity, try new experiences, or meet new challenges (Ayres IN Bundy, *et al*, 2002, p12).

The above mentioned are descriptions of symptoms, behaviours or functional problems that children experience but sensory integration dysfunctions are due to sensory processing problems and will be described according to Schaaf, Schoen, Smith Roley, Lane, Koomar & May-Benson IN Kramer & Hinojosa (2010, p 112).

a) Sensory modulation dysfunction which is characterized by atypical response to sensory experiences or situations.

b) Somatodyspraxia which includes poor ability to plan and execute novel motor actions associated with poor perception of touch and poor body scheme.
c) Bilateral integration and sequencing dysfunction which is characterized by poor ability to coordinate both sides of the body, atypical postural and ocular mechanisms associated with inefficient processing and perception of movement and body perception.
d) Somatosensory processing deficits due to poor discrimination of tactile and proprioceptive information
e) Vestibular processing deficits which includes poor awareness and tolerance of gravity and movement through space
f) Visuodyspraxia which includes poor visual perception and visual motor integration.

These manifestations may occur individually or together in affected children.

2.2.3.1 Modulation disorders

Sensory Modulation disorders occur when the child is unable to regulate his brain's activity by inhibiting some neural responses while intensifying others. This may result in insecure, anxious behaviour and difficulty processing information and comprehending its meaning (Ayres, 1979 IN Bundy *et al*, 2002, p8; Abraham, 2002, p10). Some literature subdivides modulation disorders into four main types: sensory defensiveness, gravitational insecurity, aversive responses to movement and underresponsiveness (Bundy et al, 2002, p9). Winnie Dunn, the author of the Sensory Profile, proposed a model where four behavioural patterns characterise modulation disorders. A child with "sensory sensitivity" experiences distress from sensations, and becomes distracted from the task at hand, a child who is "sensation avoiding" behaves by controlling and limiting the sensations he is exposed to, a child with "low registration" seems to be unaware of sensations in his environment and internally, whereas a child who is "sensation seeking" thoroughly enjoys sensations and seeks to intensify and increase these in his behaviour and activity choices (Dunn, 1997 IN Ben-Sasson, Cermak, Orsmond, Tager-Flusberg, Carter, Kadlec & Dunn, 2007, p 584).

Sensory Modulation dysfunction is hypothesised to have roots in the hypothalamus and limbic system. The hypothalamus is responsible for mediating the autonomic nervous system, which is activated by anxious behaviours, which manifest in physiological changes, including increased heart rate, increased respiration, papillary dilation and suppression of appetitie (Bear *et* al, 2007 IN Reynolds & Lane, 2009, p434; Bear, Connors & Paradiso IN Reynolds & Lane, 2009, p434). The limbic system is the body's "emotional mediator" and furthermore plays a role in learning, memory feeding behaviours, aggression, motivation and emotional expression. It consists of three cortical areas (cingulate gyrus, septum and parahippocampal gyrus), the grey matter of the hippocampus and the amygdala. The amygdala is hypothesised to be responsible for storing emotional memories of past events, and is known for activating emotions in response to incoming stimuli. The storage and retrieval of emotional memories from the amygdala may inhibit the ability of the frontal cortex to inhibit emotional over-responsivity to current events and sensations (Bear *et al,* 2007 IN Reynolds & lane, 2009, p434). The limbic system is well connected with other areas of the central nervous system, receiving input from all cerebral lobes and connecting fibres. It projects extensively with in itself as well as to all lobes. An important projection in the limbic system is from the reticular formation, forming a connection between arousal states, readiness to cope with incoming stimuli and emotional memory (Reynolds & Lane, 2009, p434). Ayres (1972) proposed that deficits in the child's ability to modulate incoming sensory stimuli may lead to the manifestation of stress-related behaviours, including anxiety and distractibility (Ayres, 1972 IN Reynolds & Lane, 2009, p433). Many children with sensory modulation difficulties have significant emotional and social difficulties, and may respond inconsistently (Bundy *et al*, p110).

Children who over respond to incoming sensory input, react very strongly, and often negatively, to sensations they are sensitive to or are attempting to avoid (Dunn, 1997 IN Ben-Sasson *et al*, 2007, p584). According to Winnie Dunn's model (Dunn, 1999), these children have low neurological thresholds. They need very little input to elicit a response, and often react intensely and negatively to stimuli that would not cause a reaction in others, gaining them the description of being "sensory defensive". They try to avoid or withdraw from stimuli which they find upsetting or unpleasant, and lash out at the source of the input if withdrawal is not possible. These responses are an indication of the activation of the sympathetic nervous system (Bundy *et al*, 2002, p108).

Gravitational insecurity is a fear of movement or a change in body position out of an upright, aligned position, with feet off the floor. This reaction is a defensive response, caused by poor processing of vestibular sensations from the utricle and saccule and possibly insufficient vestibular-ocular integration (Ayres, 1979 IN May-Benson & Koomar, 2007, p143). The elicited reaction is intensified and out of proportion to any real or apparent danger and postural deficits the child may have (Bundy *et al*, 2002, p9). Aversive responses to movement are characterised by intense reactions to movement most individuals would find pleasant or non-noxious, and involve autonomic nervous system reactions, such as sweating, nausea, respiratory rate changes and pallor. The intense reaction is believed to arise due to inefficient processing of vestibular sensations from the semi-circular canals (Bundy *et al*, 2002, p10). Gravitational insecurity has been associated with perceptual difficulties such as poor depth perception, insufficient visual input during the performance of motor tasks and difficulty integrating input from the visual, vestibular and proprioceptive systems (Bloomberg, Mulavara, & Cohen, 2001 IN May-Benson & Koomar, 2007, p143). The difficulty integrating multi-system stimuli is thought to possibly contribute to children with gravitational insecurity having higher resting sympathetic arousal rates than their peers (Weisberg, 1984 IN May-Benson & Koomar, 2007, p143), with performance in activities where the position of the head changes further increasing these arousal levels.

Children, who underrespond to stimuli, seem to have dulled responses. They need more input in order for the behavioural system to become activated, and thus may engage in sensory seeking behaviours (Dunn, 1997 IN Ben-Sasson *et al,* 2007, p584). Underresponsiveness suggests a less intense reaction than seen in most individuals under the same circumstances. Dunn proposed a conceptual model linking neurological thresholds to behavioural responses to stimuli. Children who are underresponsive are said to have high neurological thresholds, requiring intense or a lot of input for a reaction or response to be elicited. They may behave by being unaware of incoming sensory input, or may seek input. These children are prone to danger and injury due to their underresponsiveness (Bundy *et al*, 2002, p108).

Some children are hyporesponsive at times and hyperresponsive at others. There seems to be a complex, circular relationship between hypo and hyperresponsiveness. This child responds with defensive reactions to sensory input until the input reaches a level where he can no longer cope with it, and he enters a shutdown phase in sensory processing. This shutdown is exhibited by behaviours mimicking hyporesponsiveness (Bundy *et al*, 2002, p109, Royeen and Lane IN Bar-Shalita, Goldstand, Hahn-Markowitz and Parush, 2005, p148).

Poor sensory processing abilities in children may have and affect on their social, cognitive and sensory-motor development (Dunn, 2001 IN Yochman *et al*, 2004, p295).

2.2.3.2 Practic disorders

Praxis is the ability to plan (ideate), organise (motor planning), and execute unfamiliar or novel motor actions in response to the environment (Schaaf, Schoen, Smith Roley, Lane, Koomar & May-Benson IN Kramer & Hinojosa, 2010, p 142). It is central to how children learn to play, problem solve in activities, learn about the characteristics of objects and the effect they have on them, and participate in sporting activities. Praxis relies on accurate sensory integration, which forms a solid foundation from which the child can increase their repertoire of skills (Murray-Slutsky & Paris, 2005, p28).

According to Parham and Mailloux (IN Case-Smith & O'Brien, 2010, p349, 350) Ayres "was struck" with the relationship between tactile perception and praxis due to the fact this relationship kept on emerging in studies. Ayres therefore hypothesized for the development of an accurate body scheme, good tactile perception is of essence. A good body scheme then serves as a "reservoir" to draw from during the planning of actions.

Ayres was the first to use the term somatodyspraxia describing a sensory integration dysfunction which is characterized by poor praxis and poor tactile and proprioceptive processing (Parham and Mailloux IN Case-Smith & O'Brien, 2010, p349; Ayres IN Mailloux, Mulligan, Smith Roley, Blanche, Cermak, Coleman, Bodison and Lane, 2011, p144). Children do experience motor planning problems that are not related to problems within the tactile and proprioceptive systems (e.g. some children with cerebral palsy or nonverbal learning disabilities), but these types of motor planning problems are not considered to be sensory integration dysfunctions. According to Schaaf, Schoen, Smith Roley, Lane, Koomar & May-Benson (IN Kramer & Hinojosa, 2010, p 140) somatodyspraxia is the most common type of dyspraxia seen in children.

Children with somatodyspraxia will display problems including clumsiness, poor execution of self care activities such as dressing and eating, they can be disorganised, do not always know the boundaries of their bodies and will therefore easily invade other people's personal space (Schaaf, Schoen, Smith Roley, Lane, Koomar & May-Benson IN Kramer & Hinojosa, 2010, p 141). They easily break things and also experience difficulties in the handling of tools such as pencils and scissors. They also have specific difficulties with oral praxis and therefore they can experience functional problems such as not chewing food properly and poor articulation during speech. Children need to feel in control and achieve success in tasks to feel safe in their environment and build a healthy self esteem. If they have difficulty with praxis, expectations placed on them to participate in tasks may cause a lot of stress and anxiety. Activities become a struggle, involving more energy and effort than what is put in by peers with normal practic skills (Murray-Slutsky & Paris, 2005, p32; Bundy, *et al*, 2002, p82).

Visuodyspraxia is a practic dysfunction characterised by an inability to use vision to direct hand and body movements (Schaaf, Schoen, Smith Roley, Lane, Koomar & May-Benson IN Kramer & Hinojosa, 2010, p 145). Functions such as visual form and space perception, figure ground perception, visual motor integration and visual spatial abilities can be affected.

Visuo and Somatodyspraxia (SIPT group 3) is a dysfunctional prototype. There are slight differences between the scores obtained for children considered to have visuodyspraxia and children considered to have somatodyspraxia, although these scores are clustered together in the group 3 pattern. Group 3 (visuo and somatodyspraxia) characteristically have low scores in: Design Copying, Standing and Walking Balance, Sequencing Praxis, Kinaesthesia, Bilateral Motor Coordination, Graphesthesia, Finger Identification, Postural Praxis and Motor Accuracy. The lowest scores are found in Design Copying and Standing and Walking Balance, with a slight increase noted in the order of tests listed. The rest of the scores in the SIPT are between -0.4 SD and -0.09 SD. Praxis on verbal Command achieves a score notably higher than the other tests. Further analysis is needed to distinguish between visuo and somatodyspraxia (Ayres, 2004, p133).

In visuodyspraxia, dysfunctional children load with low scores, ranked lowest to highest, on Motor Accuracy, Design Copying, Space Visualisation, Figure Ground, Constructional Praxis, Finger identification, Standing and Walking Balance and Manual Form Perception. Low scores on two of the four tests of Motor Accuracy, Design Copying, Space Visualisation and Constructional Praxis, along with a low score in Finger Identification is associated with visuodyspraxia (Ayres, 2004, p133).

Separately from visuodyspraxia, somatodyspraxia is characterised by low scores in Postural Praxis, Constructional Praxis, Oral Praxis, Graphesthesia and Finger Identification. The tests for Oral Praxis and Postural Praxis have the highest linkage with tactile perception and are thus considered the best representation for somatodyspraxia in the SIPT. Generally, the lowest scores are achieved in tests of Oral Praxis, Postural Praxis and Sequencing praxis. There are consistent deficits in somatosensory processing in children in this prototypic group, characterised by deficits in Standing and Walking Balance, Localisation of Tactile Stimuli, Kinesthesia, Graphesthesia, and Finger Identification; all tests strongly associated with indicating somatodyspraxia (Ayres, 2004, p133).

Group 5, Dyspraxia on Verbal Command, is considered to be the most discrete and least variable group. A characteristic score pattern in this group in a very low score in Praxis on Verbal Command, coupled with a higher Postrotary Nystagmus Score. This is a dysfunctional pattern not seen in normal children. Scores in Design Copying, Oral Praxis, Sequencing Praxis, Bilateral Motor Coordination and Standing and Walking Balance are moderately low (-1.0 SD to -1.6 SD). The other somatosensory tests, visual form and space perception tests and visuopraxis tests score in the average to low average range. High scores may be obtained in Postrotary Nystagmus, Localisation of Tactile Stimuli, Finger Identification, Space Visualisation and Constructional Praxis (Ayres, 2004, p133). This disorder is considered to be based in language processing, and an indication of left cerebral hemisphere functioning rather than a sensory integrative disorder (Ayres in Mailloux *et al*, 2011, p144).

2.2.3.3 Bilateral Integration and Sequencing Dysfunction

This dysfunction is characterized by difficulties in coordinating the two sides of the body in activities. The sequencing of steps in an activity also poses definite challenges for children with this type of disorder. The vestibular- and proprioceptive systems is implicated in bilateral integration and sequencing dysfunction (Schaaf, Schoen, Smith Roley, Lane, Koomar & May-Benson IN Kramer & Hinojosa, 2010, p 142, 143.)

A deficit in Bilateral Integration and Sequencing (SIPT group 1), is considered to be the purest and cleanest picture of a bilateral; integration and sequencing deficit. The scores achieved in all subtests in this group are in the average range; however the lowest scores achieved are significantly below the others (Ayres, 2004, p132). There may also be a noticeable and significant contrast in scores in the presence of a presenting problem. The constellation of scores in this prototypic pattern is ranked from lowest to higher as follows: Oral Praxis, Graphesthesia, Standing and Walking Balance, Sequencing Praxis, Postural Praxis and Bilateral Motor Coordination. Five of these scores, excluding postural praxis, have shown to be the best indicators of bilateral integration and sequencing function across all analysis. Tests that score in a narrow average band, between 0.2 SD and -0.2 SD are Space Visualisation, Figure Ground, Manual Form Perception, Finger Identification, Localisation of Tactile Stimuli, Praxis on Verbal Command, Design Copying, Constructional Praxis and Motor Accuracy. In this prototypic pattern, highest scores are achieved in Praxis on Verbal Command and Constructional Praxis. The contrast between the scores obtained in Bilateral Integration and Sequencing Tests (Oral Praxis, Graphesthesia, Standing and Walking Balance, Sequencing Praxis and Bilateral Motor Coordination) and other tests are key to diagnosing a child as being part of this group. The bilateral motor coordination score still remains the purest indicator of bilateral integration functioning (Ayres, 2004, p132).

2.2.4 Sensory Integrative Dysfunction and Play

Norma Alessandrini, in the American Journal of Occupational Therapy, 1949 states:"Play is a child's way of learning and an outlet for his innate need of activity. It is his business or his career. In it he engages himself with the same attitude and energy that we engage ourselves in our regular work. For each child it is a serious undertaking not to be confused with diversion or idle use of time. Play is not folly. It is purposeful activity." (IN Parham & Fazio, 2008, p3).

Children have an innate drive to play, and it forms the base from which they learn to interact with and understand their world. Social participation, or play in the child's context, is an area that can be affected by health status and disability, according to the World Health Organisation's International Classification of Functioning (Cosbey, Johnston and Dunn, 2010, p463). Children tend to choose play activities within their capabilities and level of function, and tend to choose playmates with the same play skills (Rubin, Lynch, Complan, Rose-Krasnor & Booth, 1994 IN Cosbey *et al*, 2010, p462).

The purpose of this study is to determine the prevalence of sensory integrative disorders in children with cancer. Previous studies and literature have reported neurocognitive and behavioural side effects of cancer treatment **(Section 2.5)**, and the experience of trauma on the child **(Section 2.6)** as well as the effect of long term hospitalisation on the development of sensory processing **(Section 2.7)** is discussed. These events all have an influence on the child's play, and thus the development of the child. Children who are experiencing side effects of cancer treatment, or are hospitalised for long periods of time due to illness, may not feel well enough to participate in learning and play activities (Keene, 2002, p188), and may thus lose out on opportunities to develop physical, problem solving and social-interactive skills. Literature on play was included here, because of the fundamental role play has in the child's development, and the influence of sensory integrative disorders, hospitalisation and cancer treatment on this. Bundy suggested that "a child who is playful has more internal control, is more intrinsically motivated, is freer from some constraints of reality, and is better able to give and receive interactional cues than a child who is less playful" (Bundy, 1997 IN Okimoto, Bundy & Hanzlik, 1999, p74).

Play is the primary occupation of children. It is intrinsically motivated, emphasises the process of activity, voluntary, generally participated in for enjoyment and pleasure, carries an element of spontaneity and fun, and requires active engagement from participants (Parham & Fazio, 2008, p4, 5). To play optimally, a child must act on his environment in an effective and efficient manner (Bundy, Shia, Qi & Miller, 2007, p201).

Play is an important aspect in the development of socialisation, as children learn norms and social rules through interaction with others. These norms and rules provide a framework for interaction with familiar and unfamiliar people in the child's environment, and sets the base for interactions in adult life. Role playing games, where roles switch, assist in developing perspectives and behaviour adaptation. These in turn participate in developing the child's self esteem, awareness of others, and awareness of the collective group (Parham & Fazio, 2008, p14).

The presence of a disability/dysfunction provides a special challenge to play. Children with physical disabilities limiting their ability to physically participate in many of the play activities participated in by children of their age; tend to be onlookers in play situations. The quality of their interaction is influenced by their physical limitations. In a study by Okimoto, Bundy and Hanzlik, children with disabilities were found to score lower on the test of playfulness (ToP) than non-disabled children matched for cognitive age and gender (Okimoto, Bundy & Hanzlik, 2000, p 79). Children with invisible disabilities, such as sensory integrative difficulties often experience difficulties in play. Pre-school boys with sensory integrative difficulties received lower play scores, and engaged in less outdoor social play in a comparative study with same aged boys without sensory integrative difficulties, using Knox's Play scale as a tool (Bundy 2001 IN Parham & Fazio, 2008, p27; Bundy *et al*, 2007, p201). These children tend to participate more freely and regularly in play activities where their skills are the strongest. This may be an effective coping strategy in the short term, and may result in preservation of the child's self-esteem, but these limited play opportunities limit the child's ability and opportunity to develop social and motor skills essential to interactions in his environment (Parham & Fazio, 2008, p28). Children with developmental coordination disorder (DCD) tend to engage in less active play, once again missing out on opportunities to master important skills (Parham & Fazio, 2008, p28).

The inter-relationship of sensory integration and play depends on the development of various neurobiological capacities, specifically the drive for receiving, perceiving and integrating sensory information with motor responses (Milller & Miller-Kuhaneck, 2006a, 2006b IN Parham & Fazio, 2008, p263). Refinement of sensory integration provides scaffolding for participation in increasingly complex play behaviours, which in turn further sensory integrative development.

During the preschool years, children are predominantly involved in constructive play. Imaginary and social play skills emerge in this time too (Knox, 2005 IN Parham & Fazio, 2008, p264). Children in this age group enjoy basic sensory experiences. Play becomes more intricate, with more complex interactions, including language and symbolic thought being included. Sensory integration skills that are being practiced here provide a foundation for interactions in later life, including complex conceptual and social functions. Neuronal models are set in motion for the properties and workings of items in their surroundings as children explore sensory and motor aspects in play experiences (Parham & Fazio, 2008, p265).

During school years, more sophisticated play styles, with rules and skills emerge (Knox, 2005 IN Parham & Fazio, 2008, p265). Motor skills dependant on efficient sensory integration and praxis are important in this time. If the child has inefficient sensory processing, his social status, motivation and self-esteem may be threatened. Many games participated in by school aged children are skill based, such as sport. Other games and activities such as riding a bicycle, roller blading, ice-skating and building models require a great deal of practic skill, making these significantly challenging for a child with a sensory integrative based practic disorder. Intact sensory Integration is essential for a child to be able to participate in these games and activities with a degree of skill and success (Parham & Fazio, 2008, p266).

Children who have sensory integrative difficulties have difficulty playing as their peers and children with normal sensory integration do. They may avoid certain games or play activities, play in a different way, or experience significant difficulties with tasks and activities. Their play is less diverse in quality and quantity (Koenig & Rudney, 2010, p432). Sensory seekers seek varied, novel and intense stimuli from their environment, and in their choice of play activities. They often engage in games such as body contact sport and activities involving complex, intense and novel sensory stimuli (Parham & Fazio, 2008, p11). Children who have difficulty registering sensory information seem unaware of the sensory information in their environment, and don't focus their attention on this or on non verbal or subtler aspects of play and social interactions (Benson, Nicka & Stern, 2006, p2).

Children who have difficulties with sensory modulation, have unusually heightened, diminished or fluctuating responses to sensory input.

Tactile hypersensitivities may occur in areas of the body rich in tactile receptors, such as the hands, feet and face. Children who are hypersensitive to tactile stimuli (sometimes referred to as "tactile defensive") have their play influenced in profound ways. Much play in infancy is centred around the tactile exploration of objects, with infants touching and mouthing many different objects. A child's tendency to avoid tactile exploration of objects in infancy, limits the opportunities for development of many skills, including spoken language, visual perception, sensory integration, tool handling and manipulative skills. In later childhood, these children avoid play with messy objects such as sand, finger paint, dough and art materials, once again limiting the opportunities open to them to develop skills. This avoidance may also have an impact on their ability to socialise and make friends, as they are not happily participating in the same activities as their peers. These children are often fussy feeders, with limited diets and food tolerances, once again threatening their ability to socialise and interact in situations like children's parties. Children with hypersensitivity to tactile input may react aggressively to touch from others and may lash out when someone touches or brushes up against them unexpectedly. This definitely has a negative impact on socialisation and formation of friendships in childhood, as the lashing out and unpredictable, aggressive behaviour isolates the child. Childhood activities and games like face painting and dressing up in costumes and accessories is unpleasant and disorganising to these children. They tend to avoid these activities, and are unhappy and unmodulated when they are required to participate in them for school plays or at parties (Parham & Fazio, 2008, p268).

Auditory sensitivities influence children's play, development and socialisation as they tend to avoid situations which become noisy, like birthday parties and group games. Many children's toys, such as electronic toys and cause and effect toys have sound effects. Children with auditory sensitivities may avoid these games, and thus miss out on learning and skill development activities (Parham & Fazio, 2008, p268).

Children with gravitational/movement insecurities respond fearfully to movement, in a manner which is out of proportion to the stimulus received. These children tend to avoid movement based activities, games and playground equipment. Avoidance of these activities and games results in a host of difficulties and loss of opportunity for development of skills and sensory integration. The vestibular system is closely linked with neurologically based functions like the development of extensor muscle tone, balance and equilibrium, eye movements, coordination and bilateral skills; hence avoidance of movement activities will impact on the development of these areas. A child who is in a constant state of fear and anxiety has a limited ability to participate in social interactions (Parham & Fazio, 2008, p268).

Children with Bilateral and Sequencing Disorders have poor postural mechanisms, inadequate bilateral integration, underresponsive vestibular systems and experience difficulties sequencing tasks (Ayres 2005, p73-75). This is a less severe sensory integrative disorder, and although the effect on academic skills can be quite noticeable, the effect of this disorder on children's ability to play and choices made in play is more subtle. These children may engage in vestibular seeking behaviour due to the inefficient processing of information in this system, and may spend more time moving, spinning and swinging than their peers, without showing the expected signs of nausea. These differences in play behaviour become more obvious as the child gets older, as much play in younger children is centred around sensory seeking behaviours and sensory exploration. Difficulties with bilateral integration and laterality make participation in team sports and activities such as choreographed dancing and cheerleading difficult for children, as they get confused with directions (Parham & Fazio, 2008, p269).

Dyspraxia has a more profound effect on children's ability to play, as they have difficulty coming up with an idea and a plan to play. The constantly changing themes, actions and sequences are a significant challenge to them, and they are often unsuccessful at reaching these goals. Dyspraxia often occurs with a sensory processing disorder, where information from one or more sensory systems is not processed accurately, leading to faulty internal information from which an action is generated (Parham & Fazio, 2008, p270).

Children with sensory processing disorders tend to engage in more sedentary play than their peers probably because active play requires the ability to maintain an optimal state of arousal and is more demanding on motor skills (Bundy *et al*, 2007, p204). They may also be more isolated in social situations, preferring to assume the role of the observer rather than active participant (Koenig & Rudney, 2010, p432).

2.3 CHILDHOOD CANCER

Childhood cancer is a fairly rare disease, carrying with it immense fear and anxiety. Due to advances in medical treatment, many children diagnosed with cancer can be cured and go on to lead almost normal lives. The commonest forms of cancer in children are brain tumours, abdominal tumours, leukaemia and lymphoma. With early identification and diagnosis, and appropriate treatment at an oncology centre, cure is a very real possibility (Janes-Hoder & Keene, 2002, p xi). This section highlights the types of childhood cancer forming part of the study population, investigations needed to make the diagnosis and the medical course of action followed in treatment.

Early warning signs of childhood cancer, which warrant special investigation, are:

1) Pallor plus bleeding, unexplained bruising, purpura and oozing of blood from the nose or mouth.
2) Bone pain not localised to one area, intense enough to wake the child at night. Development of a limp and reluctance to weight bear on a limb, or the presence of backache.

3) Persistent, unexplained localised lymphadenopathy with enlarged glands not responding to antibiotics.
4) Unexplained neurological signs including headaches, early morning vomiting, ataxia and cranial nerve palsy.
5) The presence of an unexplained mass in the abdomen, testes, head, neck or limbs.
6) Unexplained and persistent fever, apathy or weight loss on exclusion of infections.
7) Ophthalmic changes including a recent development of a squint, white reflex, proptosis or visual loss (www.saccsg.co.za).

2.3.1 Neuroblastoma

This is a solid tumour in the sympathetic nervous system, occurring most commonly in children under five, with the average age at diagnosis being two years. It mostly occurs spontaneously, although children with Hirschprung's disease or von Recklinghausen neurofibromatosis seem to have an increased risk (Janes-Hodder & Keene, 2002, p125). It can occur at any point along the sympathetic nervous system tract, which is part of the peripheral nervous system, connecting the central nervous system (brain and spinal cord) to the organs and body systems. This system reacts automatically in response to a person's emotions as well as environmental factors, by altering heart rate, blood sugar and body temperature. More than half of Neuroblastomas originate in the adrenal glands, small glands above the kidneys, which are responsible for the production of cortisone, aldosterone and stress hormones (Janes-Hoder & Keene, 2002, p124). The first indication of the presence of this tumour is generally a lump in the abdomen, felt by the parents while dressing or bathing the child. Loss of appetite, swollen abdomen, weight loss, diarrhoea and vomiting are also warning signs. Many children present with fatigue, irritability and fever. If the disease has spread to the skeleton, bone pain, limping, refusal to stand and "raccoon eyes" (dark circles around the eyes indicating a spread to the eye sockets) accompany the previous symptoms (Janes-Hodder & Keene, 2002, p126). A diagnosis of Neuroblastoma is confirmed after a thorough physical examination, full blood count, a131 I-meta-iodobenzylguanine (MIBG) scan to assess bone, lymph node biopsy, computed tomography (CT) scan, magnetic resonance imaging (MRI) and chest x-rays , tumour biopsy, bone marrow aspirations and biopsies from each hip, urine and hormone tests (Janes-Hodder & Keene,2002, p128). Treatment is chosen based on the risk category the child is determined to fall in after analysis of the examination results. The treatment varies in aggression and may consist of a combination of surgery, chemotherapy, radiation therapy and occasionally peripheral stem cell transplantation. Chemotherapy drugs used in the treatment of this cancer are carboplatin, cyclophosphamide, doxorubicin, etoposide, ifosfamide, cisplatin, topotecan, irinotecan and melphalan, in varying combinations depending on protocols used and risk factors determined. The goal of treatment is to achieve complete remission, where all signs and symptoms of neuroblastoma are absent on standard evaluation (Janes-Hodder & Keene, 2002, p131-133).

2.3.2 Wilms Tumour

Wilms Tumous, also known as Nephroblastoma, is a childhood cancer originating in the kidney. This is the second most common type of childhood solid tumour, accounting for about 6 % of childhood cancers in the United States of America, with peak prevalence being before the age of five years. It may occur in one or both kidneys. There is increased prevalence of this cancer among black children, with girls being more susceptible (Janes-Hodder & Keene, 2002, p138, 139). Wilms tumour has been associated with genetic mutations and birth defects including Aniridia, WAGR syndrome (Wilms tumour, Aniridia, Genitourinary tract abnormalities and Mental retardation), Beckwith-Wiedemann syndrome, Hemihypertorphy, Denys-Dash syndrome, Nephroblastomatosis, Perlman syndrome, Simpson-Golabi-Behmal syndrome, Sotos syndrome, Bloom syndrome and Hereditary Wilms tumour. There have been no confirmed environmental factors leading to an increased risk for developing Wilms tumour (Janes-Hodder & Keene, 2002, p140). One of the first warning signs of Wilms tumour is an abdominal mass, noticeable to the parents during bathing or dressing the child. It may also be discovered during routing examinations by a paediatrician, or incidentally after abdominal trauma or other incidents. Children may present with abdominal pain, heamaturia, high blood pressure, fever, diarrhoea, weight loss, shortness of breath, anaemia or urogenital infections (Janes-Hodder & Keene, 2002, p141). A diagnosis of Wilms tumour is made after a thorough physical examination, including abdominal ultrasound, contrast CT, blood and urine analysis and kidney function tests, chest x-rays, and chest CT. Wilms tumour has a good prognosis, and improvements in treatment protocols have greatly improved survival outcome of these children. The general course of treatment is surgical removal of the tumour and kidney (or part thereof), chemotherapy and possibly radiation. Chemotherapy protocols usually consist of a combination of dactinomycin, vincristine, doxorubicin, etoposide and cyclophosphamide, depending on the stage and histology of the tumour. The duration of treatment depends on the stage and histology of the tumour, and lasts eighteen weeks to six months (Janes-Hodder & Keene, 2002, p141-145). Children with bilateral tumours or tumours considered to be inoperable are given chemotherapy pre-surgery to shrink the tumour first.

2.3.3 Rhabdomyosarcoma

Rhabdomyosarcoma is a childhood cancer arising in soft muscle tissue. It occurs in any muscle tissue, but the point of origin is often associated with the child's age at diagnosis. Head and neck tumours are more prevalent in children under the age of eight; limb tumours are more common among adolescents. Rhabdomyosarcomas can also occur in the bladder, prostrate or vagina, although these are less common tumours. The occurrence of Rhabdomyosarcoma seems to be sporadic, with no known environmental risk factors. An increased prevalence has however been reported in children with congenital abnormalities such as Neurofibromatosis, Li-Fraumeni syndrome or Beckwith- Weideman syndrome. The first sign of a childhood Rhabdomyosarcoma is a lump, unrelated to physical trauma. If the tumour originates in the head or neck, eyelid swelling, a bulbous eye, weakened eye muscles or double vision are among the early warning and indicative signs. Rhabdomyosarcomas occurring in the genitourinary tract may present with painful urination, blood in urine, constipation or discharge. Rhabdomyosarcoma is diagnosed after a thorough physical examination, blood tests, liver function tests, contrast CT, MRI, ultrasound and an open or needle biopsy of the mass. A bone marrow aspiration and biopsy is done to determine of the disease has spread and to assist in staging. Childhood Rhabdomyosarcoma is treated with a combination of surgery, chemotherapy and radiation, depending on the stage of disease, the staging and site and histology of the tumour. Combination chemotherapy has shown to be most effective in fighting this disease, with the most commonly used drugs being vincristine, dactinomycin, ifosfamide, cyclofosfamide, etoposide and doxorubicin. Topotecan or Irinotecan are added in some cases. Some children may benefit from stem cell transplantation (Janes-Hodder & Keene, 2002, p150 – 159).

2.3.4 Osteosarcoma

Osteosarcomas are malignant bone tumours, occurring in children and young adults with the peak incidence being between the ages of 10 and 25 years. It is found more commonly in males than in females, and an increased incidence has been reported among members of the black population. It can occur in any skeletal bone, but is commonly found in the femur or in the tibia close to the knee. Humeral tumours close to the shoulder are also common. Less common, but reported sites for osteosarcoma include the jaw, pelvis and ribs. Once again, there is an increased risk of this cancer developing in children who were born with Li-Fraumeni syndrome. Environmental risk factors include exposure to radiation, and previous exposure to cancer treating drugs, including high dose nitrogen mustard, cyclophosphamide, procarbazine and ifosfamide as well as doxorubicin, idarubicin and epirubicin. Initial indications of a possible Osteosarcoma are pain, increased temperature over the affected area, occasional swelling and unexplained limping. A diagnosis is confirmed after blood tests, urine tests, x-rays, MRI and open or needle biopsy has been completed. The course of treatment is determined by the stage of the tumour, the tumour's resectability, and its response to pre-surgery chemotherapy. A combination of surgery and chemotherapy is used to treat this cancer. Surgical options are limb-salvage surgery, where the disease is removed but nerves and blood vessels remain intact, allowing the bone to be restored with bone grafts or inserts; or amputation, where the diseased limb is removed. There are fewer chemotherapeutic agents that are used in the treatment of Osteosarcoma, with most protocols using a combination of methotrexate (in high doses), cyclophosphamide, doxorubicin, ifosfamide, etoposide, carboplatin and cisplatin (Janes-Hodder & Keene, 2002, p164 – 173).

Ewing's sarcoma is a bone cancer which is commonly found in the pelvis, femur, humerus and ribs and is particularly sensitive to radiation. There are other cancers which have been found to be similar to Ewing's sarcoma on a microscopic level, and have thus been included in the Ewing's sarcoma family; these include extraosseous Ewing's sarcoma and peripheral primitive neuroectodermal tumours (PPNET). These tumours are usually diagnosed in later childhood, with peak prevalence being between 10 and 20 years. Less than one third of Ewing's sarcomas are diagnosed before the age of 10. Boys are affected more commonly than girls, with an increased occurrence among members of the white population. No environmental factors have been linked to the development of Ewing's sarcomas and they have not been shown to occur with any increased prevalence in children with congenital disorders. The tumour does however involve a genetic mutation, where there is a translocation between chromosomes 11 and 22, resulting in the production of a new protein. Children with Ewing's sarcoma generally present with pain and swelling at the site of the tumour. Fractures at the tumour site as well as fever have also been reported. Often the presenting symptoms of the tumour mimic an infection, which can cause a delay in diagnosis. A doctor may make a diagnosis of Ewing's sarcoma after a thorough physical examination, including blood tests, urine tests, x-ray and excisional, incisional or needle biopsy. Treatment protocols include surgery, chemotherapy and occasionally radiation. Chemotherapy regimens include vincristine, doxorubicin, cyclophosphamide, ifosfamide and etoposide (Janes-Hodder & Keene, 2002, p174 – 180).

2.3.5 Acute Lymphoblastic Leukaemia and Acute Myeloid Leukaemia

Acute Leukaemias are characterised by abnormal blast cell counts. Blast cells are immature white blood cells. Acute Lymphoblastic Leukaemia (ALL) is the most common type of childhood leukaemia. This occurs when there is rapid rise in the amount of immature lymphocytes (also known as lymphoblasts) in the bloodstream. These lymphocytes would have gone on to form mature T cells or B cells. ALL is diagnosed by examining a sample of bone marrow, blood tests and a thorough physical examination. This disease is one of the most curable forms of childhood cancer with aggressive treatment. Chemotherapy is the main treatment approach, with radiation of the brain and spinal cord being used in some cases. Bone marrow transplantations are indicated in some children with high risk disease, or who have relapsed. There are various phases during the treatment of ALL, each with their own protocol and approach. During the induction phase, the main aim is to kill as many abnormal white blood cells in as short a time period as possible. This phase usually lasts about four weeks and children are generally hospitalised for most or all of it. Chemotherapy administered during this time usually includes multi-drug regimes of vincristine, prednisone or dexamethasone and asparaginase in standard risk cases, with daunorubicin, idarubicin or epirubicin being added in high risk cases. These drugs are administered intravenously, intramuscularly, orally or intrathecally. Central nervous system (CNS) prophylaxis is used in the treatment of ALL to prevent the occurrence of leukaemia in the CNS. Chemotherapy, in the form of methotrexate, hydrocortisone and cytarbine are injected directly into the cerebrospinal fluid during a spinal tap. This allows the chemotherapy to bypass the blood-brain barrier and reach the central nervous system effectively. This approach to treatment has dramatically increased the cure rate, but has resulted in an increase of treatment side effects including attentional difficulties, short term memory problems, spatial problems and academic difficulties in mathematical skills. The consolidation phase consists of high doses of drugs previously used in treatment, or new drugs as well as continued CNS prophylaxis. These drugs commonly include methotrexate, cyclophosphamide, cytosine arabinoside, 6-mercaptopurine, dexamethasone, asparaginase and thioguanine. A delayed intensification or re-induction is occasionally administered before the maintenance phase in children who were slow to respond to the chemotherapy received in the induction phase. The final phase of treatment is the maintenance phase, where low dose chemotherapy is given for a period of two to three years to kill any remaining leukaemia cells. It generally consists of a combination of 6-mercaptopurine and methotrexate, with drugs like vincristine, prednisone or dexamethasone being included as needed (Keene, 2002, p20 – 26).

Acute Myeloid Leukaemia (AML) is cancer of blood cells that would have formed into granulocytes or monocytes. It is a less common form of childhood leukaemia. The treatment is very intense, and spans a time period of six months to a year. Chemotherapy is administered in two or three phases to achieve remission, classified by complete obliteration of all cancer cells in blood, bone marrow and cerebrospinal fluid. The induction phase, at the beginning of treatment is the most intense. This phase usually consists of multi-drug combination chemotherapy, generally using cytarabine, daunorubicin, etoposide and thioguanine. All-trans-retinoic acid is administered to children with M3 subtype, or acute promyelocytic leukaemia. Methods of administration include intravenous, oral, intramuscular or intrathecal. Children are hospitalised for several weeks during this intense phase of treatment. As with the treatment for ALL, central nervous system prophylactic treatment is given to prevent the spread of the disease to the brain or spinal cord. Post-remission chemotherapy is the final phase of chemotherapy treatment, given once the child is in remission to prevent the multiplication of residual cancer cells. During this final phase, cytosine arabinoside, etoposide, doxorubicin, daunorubicin, idarubicin, thioguanine, amsacrine, azacytidine and/or cyclophosphamide may be given. If a bone marrow donor is available, an allogenic bone marrow transplant may be performed in this time (Keene, 2002, p27 – 31).

2.4 CHEMOTHERAPY

Chemotherapy is a term used to describe drugs used in the treatment of cancer. These agents aim to destroy the growth of cancer cells without permanently damaging normal cells. They are administered in a variety of ways: directly into the blood stream through an intravenous needle in the arm or hand or via a right atrial catheter, orally, intramuscularly in the thigh or buttock, intrathecally via a spinal tap with injection of drugs into the cerebrospinal fluid or occasionally subcutaneously, where they are injected into the soft tissue under the skin (Janes-Hodder & Keene, 2002, p224).

2.4.1 L-Asparaginase

L-Asparaginase (also known as Asp, L-ASP or Elspar) is an enzyme which blocks protein production in cancerous cells and thus prevents reproduction of these cells. It is administered via intramuscular injection. Children may have an allergic reaction to this drug, which may result in this particular line of treatment being discontinued. Side effects include weight loss, anorexia, headache, abdominal cramping, nausea and vomiting (Keene, 2002, p176).

2.4.2 Carboplatin

Carboplatin or Paraplatin is a platinating agent, inhibiting DNA replication, RNA transcription and protein synthesis in the cancerous cell. It is administered intravenously and may cause kidney toxicity, myelosuppression, nausea, vomiting, anorexia or altered taste perception (Janes-Hodder & Keene, 2002, p229, 230).

2.4.3 Cisplatin

Cisplatin (or CDDP, cisplatinum, is an intravenously or intra-arterially administered platinating agent, interrupting DNA replication, RNA transcription and protein synthesis. It is known to be ototoxic, and the child’s hearing should be monitored. Side effects commonly reported include nausea and vomiting, myelosuppression, anorexia, alopecia, distortion in taste perception, tinnitus, kidney damage, sodium, potassium, calcium and magnesium abnormalities and peripheral tingling or numbness (Janes-Hodder & Keene, 2002, p230).

2.4.4 Cyclophosphamide

Cyclophosphamide (or cytoxan) is an ankylating agent, preventing reproduction of cancer cells by disrupting DNA . It is commonly used in the treatment of childhood cancer, and administered intravenously. Cyclophosphamide can irritate the child's bladder, thus they are encouraged to drink plenty fluids or are given Mesna as a bladder protectant. Nausea is a common side effect, requiring anti-nausea medication before and for a time after administration of this drug. Other side effects commonly noted include myelosuppression, vomiting, diarrhoea, anorexia, alopecia and stomatitis (Keene, 2002, p178).

2.4.5 Cytarbine

Cytarbine (alternate names include ARA-C, cytosar and cytosine arabinoside) disrupts the DNA of cancerous cells. It is administered intravenously, intrathecally or subcutaneously. Common side effects of cytarbine include myelosuppression, nausea, vomiting, diarrhoea, anorexia, alopecia, stomatitis and conjunctivitis (Keene, 2002, p179).

2.4.6 Dactinomycin

Dactinomycin (alternate names are Actinomycin D, Act D and Cosmegen) is administered intravenously and interferes with DNA and RNA activity in the cancerous cell. Severe skin reactions and tissue damage can occur with leakage of this drug in the IV site. Other side effects commonly experienced whilst on treatment include nausea and vomiting, alopecia, myelosuppression and anorexia (Janes-Hodder & Keene, 2002, p234.

2.4.7 Daunorubicin

Daunorubicin acts as an antibiotic, preventing DNA formation and thus cell multiplication in cancer cells. It is administered intravenously and commonly causes stomatitis, diarrhoea, alopecia, myelosuppression, nausea and vomiting in children (Janes-Hodder & Keene, 2002, p234).

2.4.8 Dexamethasone

Dexamethasone and Prednisone are similar chemically, and they work to kill lymphocytes. Dexamethasone(or decadron) is administered in high doses as a chemotherapy and in low doses as an anti-nausea drug. Dexamethasone and Prednisone may be administered orally or intravenously. Reported side effects include mood changes, increased appetite and thirst, indigestion, food obsessions and weight gain, fluid retention, insomnia, nightmares, nervousness, hyperactivity, irritability, restlessness, visual, auditory and vestibular hypersensitivity. Children may also develop a “moon face” and protruding belly (Keene, 2002, p180, 187).

2.4.9 Doxorubicin

Doxorubicin, Adriamycin, Doxil and Rubex are alternate names for the same drug. This chemotherapy is given intravenously and acts as an antibiotic, preventing DNA forming in cancer cells and thus halting their reproduction. Commonly reported side effects include red coloured urine, myelosuppression, nausea and vomiting, hair loss and stomatitis (Keene, 2002, p181).

2.4.10 Etoposide

Etoposide (or VP-16, VePesid, Etopophos or Toposar) is administered intravenously or orally. It interrupts DNA production and causes cell death in dividing cells. Frequent side effects include anorexia, myelosuppression, alopecia, fatigue, nausea and vomiting (Keene, 2002, p182).

2.4.11 5-Fluorouracil

5-Fluorouracil, 5-Fu and Adriacil are administered intravenously, or into a body cavity through a catheter. This drug blocks DNA synthesis and RNA translation by acting as an anti-metabolite. Liver toxicity is a known side effect, as well as gastro-intestinal upsets, stomatitis, blurred vision, myelosuppression and skin darkening (Janes-Hodder & Keene, 2002, p237).

2.4.12 Hydroxyurea

Hydroxyurea, or Droxia is administered orally in tablet form, and works to interrupt DNA production. Reported side effects include myelosuppression, skin rash, itching, hyperpigmentation and radiation recall, where areas of skin previously exposed to radiation redden (Keene, 2002, p183).

2.4.13 Ifosfamide

Ifosfamide is an ankylating agent, disrupting DNA in cancer cells. It is administered intravenously, in addition to Mesna, which protects the child’s bladder. Commonly reported side effects are alopecia, myelosuppression, nausea, vomiting, dizziness, confusion and excessive sleepiness. During the administration of this drug, the child is required to urinate frequently and the urine is tested for blood (haemorrhagic cystitis is an infrequent side effect) (Janes-Hodder & Keene, 2002, p239).

2.4.14 Mercaptopurine

Mercaptopurine (alternately known as 6-MP or Purinethol) is taken orally. Pharmacologically it acts as an anti-metabolite, replacing part of the backbone of cancerous cell DNA and thus interrupting reproduction. Myelosuppression and loss of appetite are the most commonly reported side effects (Keene, 2002, p184).

2.4.15 Methotrexate

Methotrexate, Methotrex or MTX is an anti-metabolite, replacing nutrients in cancer cells and thus causing their death, which can be administered orally, intravenously or intrathecally. Side effects of administration include myelosuppression, sun sensitivity, diarrhoea, fatigue or skin rashes. If the drug is administered intrathecally, headaches, tingling down the legs and spinal irritation may occur too (Keene, 2002, p185).

2.4.16 6-Thioguanine

6-Thioguanine (6-TG) is administered orally, and acts as an anti-metabolite, replacing part of the DNA molecule backbone. Myelosuppression, nausea and vomiting have been reported as common side effects (Keene, 2002, p190, 191).

2.4.17 Tretinoin

Tretinoin, All-trans-retinoic acid, ATRA or Vesanoid is administered orally. It causes leukaemia cells to differentiate by acting against the genetic product formed by gene fusion. The differentiated cells are given the opportunity to mature. This process slows down and the cell division and growth eventually peters out. This drug may cause Retinoic-acid-APL syndrome, which includes fever, shortness of breath, fluid build up in the lungs and weight gain. Other commonly reported side effects are increased white blood cell count, headaches, nausea and vomiting, fatigue, bone pain, skin rashes, liver damage and birth defects if administered to pregnant patients (Keene, 2002, p191, 192).

2.4.18 Vinblastine

Vinblastine, an alkaloid interrupting cell decision, is administered intravenously. It can cause severe pain and burning of the surrounding tissue if it leaks out of the IV site, as well as common side effects such as nausea, vomiting, myelosuppression and constipation (Janes-Hodder & Keene, 2002, p244).

2.4.19 Vincristine

Vincristine, Oncovin or VCR is administered intravenously. This chemotherapy is an alkyloid, preventing cell division. Side effects which have been commonly reported include constipation, severe bone pain or facial pain, peripheral numbness or tingling, weakness, loss of muscle mass, alopecia, ptosis, and severe damage to skin and tissue if the drug leaks out of the IV site (Keene, 2002, p192, 193).

Childhood cancer is treated by a scientifically guided approach using multi-drug protocols. Many of these chemotherapeutic agents have unpleasant side effects, and may affect the child physically (e.g. nausea, diarrhoea, constipation, vomiting, fatigue or muscle and bone aches), or emotionally (experience of irritability, mood swings, shyness around hair loss or skin changes). Most of these side effects are reversible. Some side effects such as accidental leakage of chemotherapy from the IV site can cause severe, painful and permanent damage to the hand, arm or other tissue surrounding the drip site. Skin injuries like this in the upper limbs affect function, sensation and are a lasting reminder of an unpleasant time in the child’s life.

2.5 EFFECTS OF CHILDHOOD CANCER TREATMENT

Advances in the early diagnosis and treatment of paediatric cancers have led to dramatic increases in survival rates, especially for diseases like leukaemia. This success can largely be attributed to the use of CNS prophylaxis, including intrathecal methotrexate and multidrug regimens. The ultimate goal of cancer therapy remains curing the disease, but this is not always without costs and oncologists try to maintain a balance between effective therapy and acceptable toxicity (Moore, 2005, p51-63; Condren, Lubsch & Vats, 2005, p32-43; Espy, Moore, Kaufmann, Kramer, Matthay & Hutter, 2001, p1). The literature currently available focuses on brain tumours and acute lymphocytic or lymphoblastic leukaemia (ALL), with a gap in the published findings of side effects of treatment of other types of childhood cancer.

The brain is the target for therapy in a child with a primary brain tumour, where there is metastatic disease to the brain or where the child has a disease such as high risk acute lymphoblastic/lymphocytic leukaemia (ALL) which quickly spreads to the CNS. Treatment can comprise of surgery, chemotherapy and radiation therapy. In surgical treatment, the neurosurgical resection of the tumour can have a positive or negative effect on the child's postoperative neurological functioning. Studies generally indicate a significant inverse relationship between age and neuropsychological and neurological severities (Moore, 2005, p51-63). Brain tumour and ALL treatment frequently comprise of high dose chemotherapy, intrathecal treatment with radiation therapy delivered to the brain. This causes damage to the cortical and subcortical white matter, with calcifications being visible on neuroimaging scans of children. White matter abnormalities have also been noted in patients with ALL who were treated with chemotherapy consisting of prednisone, vincristine, L-asparaginase and intravenous methotrexate, but most of these resolved after treatment (Moore, 2005, p51-63). Neurocognitive side effects of commonly used chemotherapy have been identified too. Vincristine can cause autonomic neuropathy, encephalopathy and peripheral neuropathy; Methotrexate has been found to cause encephalopathy, chronic leukoencephalopathy, meningeal irritation, paraplegia and reversible stroke-like symptoms. Corticosteroids cause behavioural abnormalities and memory dysfunctions. Cytarabine has been found to cause encephalopathy and cerebellar dysfunction, peripheral neuropathy and paraplegia in some cases while L-Asparaginase may cause encephalopathy, confusion and behavioural abnormalities, lethargy and muscle weakness (Salmi, Toivo T, Äärimaa, Tuula, 2003, p28-31). According to Moore (2005, p p51-63), radiation therapy may result in sudden neurological deterioration following treatment, or side effects may appear after some time. Within a period of two to six months post treatment, "somnolence syndrome" may occur, associated with fatigue and an exaggeration of neurological signs. This is secondary to diffuse demyelination and is generally transient. Various neurological deficits are seen in late stages especially among younger children, possibly due to the imbalance in the development of grey and white matter.

The areas of the cortex involved in higher order cognitive skills remain vulnerable to neurotoxic agents during the prime learning period of a child's life. The dynamic phase of white matter proliferation places the brain at greatest risk of injury due to ionising radiation or chemotherapy used in cancer treatment. Cognitive deficits are associated with the extent and site of white matter damage (Moore, 2005, p51-63) and children surviving treatment for ALL have been documented to have declines in intellectual, academic and neuropsychological skills (Espy *et al*, 2001, p1). A fourfold increased prevalence of school related functional difficulties has been reported among childhood cancer survivors in the 1980's (Mulhern, Wasserman, Friedman & Fairclough, 1989, p18-25). Pre-existing learning difficulties may be aggravated by the neurotoxic effects of cancer treatment, or learning difficulties and difficulties interacting socially may be caused by the treatment, or by the prolonged hospitalisation, absence from school and subsequent loss of academic input. Specific areas of academic difficulty are noted in short term memory, sequencing, fast processing skills, and visual organisation (Keene, 2002, p299, 300).

Children diagnosed with ALL, at a risk of CNS disease (Central Nervous System infiltration), are treated prophylactically with intrathecal methotrexate in addition to systemic chemotherapy. Cranial irradiation is indicated for children at the highest risk. Children treated with cyclophosphamide, L-asparaginase, intravenous methotrexate and intrathecal chemotherapy (methotrexate, hydrocortisone, cytosine arabinoside) showed significantly poorer performance on tests of attention and memory and visual constructional abilities. They also showed deficits in computational arithmetic skills consistent with a learning disability (Moore, 2005, p51-63). There is speculation that the CNS effects as well as the neurocognitive effects of methotrexate are exacerbated by the simultaneous administration if intrathecal hydrocortisone and/or ARA-C (Espy *et al*, 2001, p 7,8).

Central nervous system effects of childhood cancer and its treatment include learning disabilities, attention disorders such as attention deficit hyperactivity disorder (ADHD) and educational and vocational underachievement. Neurological abnormalities such as poor hand-eye coordination, paresthesis, foot drop, dementia, ataxia, spasticity and seizures have also been reported (Texas Children's Cancer Centre). Children may also experience difficulties with higher cognitive conceptual abilities, memory abilities, visual motor functioning, visiographic abilities, fine motor skills (McDougal, 1997, accessed online 18/05/2011,Salmi, Toivo , Äärimaa & Tuula, 2003, p28-31), verbal fluency and academic arithmetic (Espy *et al*, 2001, p 7). There is increased vulnerability of females to neurocognitive morbidity associated with central nervous system treatment (Moore, 2005, p51-63).

According to McDougall (1997, online access 18/05/2011), children may experience effects of cancer and its treatment which include a poor body image, academic, social and psychological impairment, low self esteem and symptoms of depression. They may experience anxiety and panic, exhibit withdrawn and inhibited behaviour, be fearful of trying new things and have low emotional expressiveness.

Late effects of childhood cancer can be found in almost all organs and body systems, with varying degrees of effect on the person's functioning and quality of life. As sensory integration can be defined as the part of sensory processing whereby sensations from one or more sensory systems connect in the brain, it can be postulated that the inability of the child to correctly gather sensory information from his body and environment may lead to sensory processing disorders or simply put, difficulty in how the brain takes in, organizes and uses sensory information (Murray-Slutsky & Paris, 2005, p15). Effects in the visual system have been noted, with children experiencing blurred vision, cataracts, chronic conjunctivitis, glaucoma, retinopathy, retinal haemorrhages, headaches, irritated dry eyes, decreased acuity, squinting and poor school performance. Effects in the auditory system may occur when the tumour affects the structural development or functioning of the inner ear and the 8th cranial nerve. Radiation, chemotherapy and supportive measures such as high doses of antimicrobials contribute to hearing loss due to the damage caused to the hair cells of the cochlea. These children may experience residual fibrosis, scarring or necrosis of the ear canal, decreased or dry cerumen, tinnitus, vertigo, abnormal speech development or poor school performance (Texas Children's Cancer Centre; McDougal, 1997, online access 18/05/2011).

Neurological deficits experienced by children who have undergone treatment for childhood cancer include deficits in their ability to learn, poor memory and attention, impaired executive function, poor eye-hand coordination, parasthesias and even symptoms as severe as dementia and seizures (Texas Children's Cancer Centre). There is also evidence indicating ALL survivors experiencing difficulties in balance, walking and running when compared to age and gender matched controls (Salmi, Toivo , Äärimaa & Tuula, 2003, p28-31)

It has been postulated that CNS prophylaxis, in the form of intrathecal chemotherapy and high dose systemic chemotherapy, affects motor programming. The effect of this has been seen in the visual and verbal domains. Visual motor skills have shown to be particularly disrupted by the administration of methotrexate (Espy *et al*, 2001, p 7).

Functional problems experienced by children who have received chemotherapy, especially those who have received high doses of systemic chemotherapy and intrathecal chemotherapy, are similar to functional problems experienced by children with sensory integrative disorders. Both groups of children may experience difficulty in academic tasks related to visual spatial skills, may have difficulty with concentration, the ability to organise themselves and their environment, abstract though and reasoning and academic learning abilities (Ayres, 2005, p55). Sensory integration refers to "the neural processes through which the brain receives, registers and organises sensory input for use in generating the body's adaptive responses to the surrounding environment" (Case-Smith, 1998, p223). It can be postulated then that the neurocognitive effects of cancer treatment may result in an impaired ability to correctly receive, register and organise sensory input. Dysfunctional sensory processing may result in learning difficulties or clumsiness, both of which have been reported as effects of cancer treatment (McDougal, 1997, online access 18/05/2011, Condren, 2005, p 32-43).

2.6 TRAUMA

Children diagnosed with cancer undergo complicated, long term medical treatment regimes. Many of the medical procedures are painful, such as venipuncture, bone marrow aspirations and lumbar puncture, and may cause distress to the child (Mash & Wolfe, 2005, p362). The burden of the diagnosis of and treatment for childhood cancer may result in behavioural and emotional adjustment difficulties. Children with chronic illnesses such as cancer cope with challenges and unpredictability on a daily basis during their treatment, and show an increase in stress related symptoms, including anxiety, depression and anger. They however, show resilience in the face of these experiences and do not necessarily develop clinically significant psychiatric disorders in later life (Mash & Wolfe, 2005, p 362, 363).

The diagnosis of childhood cancer carries with it a definite threat to life, and its treatment involves many painful and invasive medical procedures, evoking intense fear, helplessness and horror (Butler, Rizzi & Handwerger, 1995, p 499-504; Stuber, Christakis, Houskamp and Kazak, 1996, p254-261). If a child experiences an event which involves a threat of death, and responds to this with fear, helplessness or disorganised and agitated behaviour, a diagnosis of posttraumatic stress disorder (PTSD) can be considered (Kaplan and Sadock, 1998, p619). Children who are experiencing PTSD develop a collection of symptoms including intrusive memories, nightmares, anger, avoidance behaviour, constricted affect, intense psychological distress on exposure to stressor cues, and an exaggerated startle response (Butler *et al*, 1995, p499-504; Kaplan and Sadock, 1998, p619). Survivors of childhood cancer have reported that the cancer experience was a severe stressor. They report experiencing intrusive thoughts, recurring dreams about their experience, fear, distress and tension at reminders of the disease or treatment, emotional numbness, detachment, memory difficulties, increased arousal, and somatic symptoms (Stuber, Christakis, Houskamp & Kazak, 1996, p254-261; Stuber, Kazak, Meeske, Barakat, Guthrie, Pynoos & Meadows, 1997, p958-964).

In a study conducted by Butler, Rizzi and Handwerger (IN Butler *et al*, 1995, p499-504), 21% of the sample group (n=72) received ratings on the PTSD Symptom Scale parent-report inventory that met the diagnostic criterion for PTSD. They reported an increased prevalence of stress-related psychological symptoms in children who were undergoing treatment, but an overall low severity of symptoms in survivors, with 7% of children who had completed all treatments exhibiting a full spectrum of symptoms . A possible explanation for the relatively low prevalence of PTSD in the childhood cancer population is that traumas most likely to result in PTSD are those which are uncontrollable and unpredictable. The treatment for childhood cancer and the associated exposure to the traumatic event continues for a significant period of time and involves more expected or forewarned traumatic experiences such as bone marrow aspirations, spinal taps and intravenous administration of medication. Children and families in this population often receive a high degree of emotional and psychological support, which may be a protective factor in the development of PTSD (Foa, Zinbarg & Rothbaum IN Butler *et al*, 1995, p499-504; Stuber, Christakis, Houskamp & Kazak, 1996, p254-261).

A study conducted among survivors of childhood leukaemia reports a 12.5% incidence rate of symptoms suggesting severe post traumatic stress, with psychological difficulties being reported in a significant subset of patients despite generally successful adaptation and resilience. Clinical manifestations of symptoms consistent with posttraumatic stress were noted in children undergoing treatment and up to 1 year after bone marrow transplantation (Stuber, Christakis, Houskamp & Kazak, 1996, p254-261).

The experience of a traumatic event in childhood has a profound effect on the functioning of the child in behavioural, cognitive, social, emotional and physical spheres (Perry, Pollard, Blakely, Baker & Vigilante, 1996, p1). Children who have experienced trauma may present with a variety of emotional and behavioural manifestations which are included in the symptoms of post-traumatic stress disorder (PTSD), such as anxieties, depressive disorders, behavioural disorders and phobias (Schwarz & Perry 1994, online access 18/05/2011; Perry *et al*, 1996, p2). Personality development may be influenced by traumatic experiences, with the child manifesting decreased impulse control and persistent fear. Neurocognitive effects of trauma such as impaired memory, poor concentration and information processing may exacerbate learning difficulties documented in children receiving intrathecal chemotherapy (Stuber, Christakis, Houskamp & Kazak, 1996, p254-266). The human brain is a complex organ, responsible for a vast number of varying functions, including processing and internalizing all experiences and sensing, processing, interpreting and storing information from the external world and internal body environment, and directing body actions and behaviour (Perry *et al*, 1996, p2; Bundy *et al*, 2002, p114,115). Traumatised children experience sensitisation of the neural response patterns associated with traumatic experiences, with exposure to seemingly minor stressors resulting in dramatic, out of proportion behavioural responses such as hyperarousal or dissociation (Perry *et al*, 1996, p2, 3). The child's neurosensory apparatus may be activated by a traumatic experience, resulting in changes in neurotransmitter release and altering intracellular chemical constituents. In the developing brain, this sensitisation and response to stimuli organise the neural systems and influence future responses. Abnormal micro environmental cues and atypical patterns of neural activity during sensitive and critical periods of development in childhood can result in mal-organisation and altered function in humour, empathy, attachment and affect regulation (Perry *et al*, 1996, p3). Trauma experiences in childhood result in over-activation of neural systems during critical periods of development due to patterns of over-activation of neurochemical cues (Perry *et al*, 1996, p4).

The association between sensory integration, sensory modulation and trauma is apparent in behaviour characterised by hypersensitivity or over arousal, sensory defensiveness, and hyposensitivity or shut down. Anxiety occurring as a direct result of a stressful experience can amplify sensory defensiveness. Trauma memories are described as being stuck in the amygdala, unable to proceed through the hippocampus to the cortex, and thus blocking the meaning-making process of the experience (Van der Kolk, 1994, p 505-529; Bundy *et al*, 2002, p114, 115).

The adult human body responds to threat by activating the “flight or fight” reaction, children however often respond in behaviours of hyper arousal or dissociation. When a threat is perceived, the sympathetic part of the autonomic nervous system increases in activity, resulting in increased heart rate, increased blood pressure, increased respiratory rate, increased muscle tone, release of stored sugar and hypervigilance. These physiological changes assist in preparing the body for defence (Perry *et al*, 1996, p4), If the child is repeatedly exposed to reminders of the traumatic event, parts of the brain involved in this hyper aroused stress-response are reactivated, leading to sensitisation of the hyper aroused response and eventual sensitisation of components of the fear response. The sensitisation of catecholamine systems results in a cascade of associated functional changes in brain-related functions (Vantini, Perry, Gucchait, U'Prichard & Stolk, 1984, p49-65; Perry *et al*, 1996, p4). Sensitisation of the brainstem and midbrain neurotransmitter systems results in sensitisation of physiological, cognitive, behavioural and emotional functions, and re-experiencing the trauma leads to dysregulation in these functions. Traumatised children often present with behaviours including motor hyperactivity, anxiety, impulsivity and sleep disturbances, and move very easily from feeling mildly anxious to feeling threatened and also to feeling terrorised (Perry *et al*, 1996, p4).

Young children often use vocalisations such as crying in the initial stages of a threat which they are unable to avoid, to indicate that they are feeling threatened. Some children who have experienced trauma respond to a perceived or real threat by presenting with freezing or oppositional-defiant behaviours (Perry *et al*, 1996, p5). Children, who have been traumatised and have developed a sensitised response, may freeze when they feel anxious or out of control. They may seem not to hear any instructions or verbal directions or appear to be refusing to participate in a specific task or follow an instruction. If this perceived threat continues, the child may dissociate from his environment and the situation. This is manifested by the child disengaging from stimuli in the external world and attending to an internal world, appearing to be unresponsive and in a deep sleep, although his eyes may be open (Perry *et al*, 1996, p5,6). Observers have described these children as numb, robotic, non-reactive, day-dreaming, staring off into space with a glazed look and acting like he was not there. In the dissociated state, vagal tone increases, blood pressure and heart rate decrease. This is caused by brainstem mediated CNS activation, causing increased concentrations of circulating epinephrine and stress steroids. The dopaminergic systems, specifically the mesolimbic and mesocortical, which are closely involved with affect modulation, become more important (Perry *et al*, 1996, p6).

The diagnosis of childhood cancer is fearful and anxiety provoking. There is a very real threat of death or severe life changes, even with the advances in medical treatment and the increased survival rates. The medical investigations and interventions to diagnose and treat childhood cancer are characterised by numerous invasive and painful procedures, including bone marrow aspirations, biopsies, surgery, injections, finger pricks and venipuncture. Other investigations such as MRIs and CT scans can be anxiety provoking to a young child. The necessary hospitalisations and forced removal from the child's social environment can cause anxiety and depression too. Many of the chemotherapeutic agents have unpleasant side effects such as hair loss, nausea, vomiting, fatigue, irritability, stomatitis and altered sensory perceptions, which once again may be stressful and unpleasant for the child. Childhood cancer diagnosis and treatment is a very stressful, threatening event, which may result in the amplification of existing sensory hypersensitivities or the development of hypersensitivities due to the child's body being in a perpetual fright, flight or fright state. This may result in the child responding with amplified hypersensitive behaviour to stimuli carrying a perceived threat, such as tactile sensations that the child feels are out of his control. In this research, particular attention is given to the child's perception of and response to tactile stimuli to the hands and forearms while his vision is occluded, a situation which may be perceived as threatening to a child with hypersensitivities who responds with fright, flight or fight.

Reacting with a fright, flight or fight response to situations carrying a perceived threat, and being in a constant state of hypervigilance or anxiety, will impact on the child's ability to participate in social situations, play activities, and learning opportunities as he is not able to maintain a calm-alert state necessary for learning and behavioural organisation (Ayres, 2005, p155, 156).

2.7 INSTITUTIONALISATION OR LONG TERM HOSPITALISATION

Long term hospitalisation has a negative effect on children's development. Children who have been hospitalised experience stress of separation from family and friends, fear of illness, painful medical procedures, enforced confinement and disruption in daily routines (Kaplan-Sanofff, Brewster, Stillwell & Bergen, IN Case Smith, 2005, p577). Long term hospitalisation, as frequently experienced by the child with cancer, may impact on play behaviour, by the child regressing to earlier stages of play development, decreased endurance and movement, shortened attention span, decreased initiative, curiosity, resourcefulness and creativity, decreased affect and increased anxiety (Case-Smith, 2005, p577; Kielhofner, Barris, Bauer, Shoestock & Walker, 1983, p305-312). Children undergoing treatment for childhood cancer are initially hospitalised for their induction chemotherapy, to allow medical staff to assess their reaction to the drugs and closely monitor them. They may get discharged after this, and receive ongoing treatment on an outpatient basis, or have periods of shorter hospital stays. These children are however more susceptible to infections and are frequently hospitalised for this cause. The period of hospitalisation may also vary, depending on the protocols followed by the individual oncology units and after taking into account factors such as distance from home to the hospital, compliance with therapy and follow up care, support systems at home, home environment, socio-economic circumstances and the child's reaction to chemotherapy. Some children may be hospitalised for the duration of their treatment, or only have short periods of time at home.

Institutionalisation is described in literature as living in a hospital or orphanage (Lin, Cermak, Coster & Miller, 2005, p139-147). These environments are characterized by limited opportunities for play, exploration and social interaction, with the main focus being medical treatment of the child for their illness. Deprived environmental conditions have shown in animal studies to interfere with development. Longer periods of institutionalisation (6-8 months) are associated with greater developmental delays, growth delays, eating problems, social behavioural problems, and attention and activity level problems (Lin *et al*, 2005, p139-147). Children are also often confined to their rooms, beds or a chair during treatment as much of it is intravenous. Often children are not strong enough or fatigue so easily, they prefer to participate in activities requiring less movement and environmental exploration (Case-Smith, 2005, p578). In the young child who is hospitalised for a prolonged period, the reduced opportunity of active engagement with environment during these early years negatively influences his ability to process and use sensory information to organize, guide and regulate behaviour in later childhood. The process through which post institutionalised children integrate sensory perception and actions may be atypically or inadequately developed (Lin *et al*, 2005, p139-147).

Children, who are being treated for childhood cancer, miss extended periods of school, and thus periods of socialisation with children and adults who are not part of the cancer community or directly related to their illness and treatment. They experience significant disruptions to their social and educational activities and normal family interactions (Keene, 2002, p288-290). A child receiving treatment for leukaemia would potentially miss 42% of the school year in the first year of treatment, with a significant percentage of the school year being missed in years 2 and 3 of treatment (Mulhern *et al*, 1989, p18-25).

2.8 SUMMARY

The available literature, reviewed in this chapter starts to provide evidence supporting the thought that behaviours noted in children with cancer, who are undergoing treatment for this disease, may be explained by a sensory integrative disorder. The assessment procedures the child undergoes to make a diagnosis of childhood cancer, and the many painful, often traumatic treatment procedures may result in post traumatic stress disorder and inadequate sensory processing as a result of that. Long term hospitalisation, as a form of institutionalisation due to its removal from reality may be a contributing factor. Late neurocognitive and neurobehavioural effects of cancer treatment have been identified, and the link between these and sensory integrative disorders is evident in a review of sensory integration literature.

From clinical experience and the available literature the question arises as to whether a child undergoing treatment for childhood cancer is at an increased risk of developing a sensory integrative disorder, characterised by observed behaviours such as inappropriate interaction with his environment, learning difficulties or poor motor skills. No literature or previous studies could be found which could answer this question. A need for such research thus exists. The study will aim to determine the prevalence of sensory integrative disorders among the childhood cancer population

CHAPTER 3:

-RESEARCH METHODOLOGY-

3.1 INTRODUCTION

The aim of this study was to determine the prevalence of sensory integrative disorders among children who are being treated for childhood cancer at three (3) State Hospitals in South Africa.

3.2 STUDY DESIGN

The study was conducted as descriptive, cross-sectional research. This type of research design provides a "snap shot" of a population at a certain point in time and allows for the researcher to calculate and describe the prevalence of a certain condition, disease or exposure to a possible risk factor in that population. This type of research design studies the relationship between different variables at a specific point in time (Katzenellenbogen, Joubert, & Abdool Karim, 2005, p67, 68). It has an added advantage in that cases do not need to be followed up and re-evaluated after a period of time for comparative purposes, eliminating the possible effect of participant mortality and absconding on the study results.

The prevalence of sensory integrative disorders among the childhood cancer population was determined by analysing the results obtained after standardised testing, and then described. Part of the description of the study results includes a description of the different types of sensory integrative disorders.

3.3 SAMPLE/ STUDY POPULATION

South Africa has nine state funded paediatric oncology units dispersed around the country. These include Johannesburg (renamed Charlotte Maxeke Johannesburg Academic Hospital), Chris Hani Baragwanath, Pretoria Academic (renamed Steve Biko Academic Hospital) and Kalafong Hospitals in Gauteng, Universitas Hospital in the Free State, Inkosi Albert Luthuli Hospital in Kwazulu Natal, Frere Hospital in the Eastern Cape and Tygerberg Children's Hospital and Red Cross Children's Hospital in the Western Cape.

Standards for Paediatric Oncology units have been developed by the International Society of Paediatric Oncology (SIOP). The paediatric oncologists who are in charge of these units follow well established international protocols for the treatment of childhood cancers. They are also all members of the South African Children's Cancer Study Group (SACCSG) and regularly meet and attend congresses where new developments and research is discussed.

The study setting consisted of three paediatric oncology treatment units, including the paediatric oncology units at Kalafong Hospital and Johannesburg Hospital (now renamed Charlotte Maxeke Johannesburg Academic Hospital) in Gauteng as well as Universitas Hospital in the Free State. These institutions have specialised units delivering care to children from Gauteng, Mpumlanga, Limpopo, North West Province, Free State, Lesotho and Northern Cape. These units provide treatment on an inpatient and outpatient basis. The units are staffed by multidisciplinary teams, comprising of paediatric oncologists, paediatric registrars, physiotherapists, dieticians, occupational therapists, nurses, social workers and music therapy students (intermittently during the year).

Convenience sampling was used to attain the sample group for this study. The study population was limited to children receiving treatment for childhood cancer at the three chosen units. Each available child, diagnosed with and receiving treatment for childhood cancer, falling in the four to eight year age group, not in exclusion criteria group and not acutely ill was assessed for sensory integrative disorders using the Sensory integration and Praxis Test (SIPT) (Ayres, 2004). Fourteen of these children were assessed using the Sensory Profile (Dunn, 1999) caregiver questionnaire as well.

Children who were in acute pain were not assessed at that time as the experience of acute pain affects the child's motivation, mood, concentration and ability to focus on the task at hand. These children were evaluated at a later stage, when their pain was under control. Children suffering from acute side effects of chemotherapy, such as nausea, vomiting and fatigue were not assessed until these symptoms had passed (usually within a few days), to ensure optimal participation in the testing procedure and reliable results (Pervan, Cohen & Jaftha, 1995, p366-376).

The evaluations took place in the paediatric occupational therapy departments of the three hospitals, or in a quiet area in the oncology wards, or the lodger mothers unit. All these are familiar, comfortable places for the children and assisted in decreasing any anxiety they may have felt about the test situation. They were permitted to bring their mother or primary care giver along for the evaluation if they felt anxious about coming alone. The areas chosen for evaluations had the necessary equipment and apparatus such as a desk and chair, sufficient space, and equipment for clinical observations set up before the child entered.

A translator who was proficient in English as well as South Sotho, Zulu or North Sotho was used to assist with testing the child in his home language, if the child was not adequately proficient in English or Afrikaans. The translator was an occupational therapy assistant or other identified individual who is comfortable with and able to establish a rapport with children and proficient in the child's language. Instructions for the test items in the SIPT were given by the researcher, and translated for the child by the identified translator if needed. Instructions for children proficient in English or Afrikaans were given by the researcher, who is an appropriately qualified occupational therapist and qualified in the administration and interpretation of the SIPT. An additional therapist assisted with data collection of four (4) children at Universitas Hospital. She was appropriately qualified in the administration and scoring of the SIPT and the Sensory Profile. Complete test packs, comprising of the booklets and child response sheets for the SIPT, a data sheet and an informed consent letter in the preferred language were compiled for each child to ensure the same procedures were followed for each child in each of the study settings. The child's mother or a nurse closely involved with the daily care of the child, and who knew him or her well, was asked to complete the caregiver questionnaire from the Sensory Profile.

3.3.1 Inclusion and Exclusion criteria

Inclusion criteria

- All children who have been diagnosed with and are receiving treatment for childhood cancer, regardless of the length of treatment received or whether it is an initial diagnosis or a relapse, who are between the ages of 4 years and 8 years 11 months and did not meet any of the exclusion criteria.

Exclusion criteria

- Children with primary central nervous system tumours were excluded from the study as these children have varying degrees of neurological involvement and may have depressed levels of consciousness and arousal which will result in very poor scores on the standardised tests and result in skewed interpretation and analysis of data. The presence of a space occupying lesion in the cranium causes neurological signs and symptoms, including blurred vision, disorientation, lethargy, decerebrate or decorticate movements and seizures, as it displaces other structures (Pervan *et al*, 1995, p363 - 376).
- Children who have had amputations of any limb (arm of leg) were excluded as they would have not been able to perform many parts of the SIPT and thus results would have been unreliable.
- Children who have been diagnosed with bilateral retinoblastoma were excluded as many of the tests require a degree of functional vision.
- Children with spinal cord infiltration and resultant paraplegia or quadriplegia were excluded as they would not have been able to perform all subtests of the SIPT.

3.4 DATA COLLECTION

Data collection was done by the researcher herself, and one other occupational therapist formally trained in the administration of the appropriate formal test (SIPT) and the assistance of a translator proficient in the language of instruction, if the child did not understand English or Afrikaans, as it is important for the child to grasp the meaning of the instruction (Ayres, 2004, p12).

In order to qualify for the administration of the SIPT test, a therapist has to attend at least a Sensory Integration Theory and Test Mechanics course presented by the South African Institution for Sensory Integration. The instructions for the administration of the SIPT and the Sensory Profile are currently available in only English and Afrikaans. Data was recorded on the approved recording sheets of the SIPT and the Sensory Profile. These were kept locked away in a safe place until analysis. Demographic information, medical information, behaviours noted and the scores obtained from the SIPT and sensory profile were transcribed onto a data sheet and coded **(Appendix 4).** The SIPT test is marked by a computer programme, allowing for convenient and immediate storage of an electronic data set for each child in addition to paper copies.

3.4 1 Measurement

The measuring instruments used consisted of the Sensory Integration and Praxis Test (SIPT, 8th print, 2004) and the Sensory Profile (Dunn, 1999).

3.4.1.1 Sensory Integration and Praxis Tests (SIPT)

The SIPT consists of 17 subtests, testing the status of a child's sensory integration or its dysfunction. This test is designed for use with children from 4 years to 8 years 11 months. It is designed to assess aspects of vestibular, proprioceptive, kinaesthetic, tactile and visual processing as well as various practic (motor planning, ideation and execution) abilities. The test also provides information regarding the various behavioural manifestations of disorders in integration of sensory inputs from the mentioned systems. Audition, olfaction and gustation are not assessed by this test. The test is administered individually in a quiet, well-lit room, free of external distractions. The room should contain a child-sized table and two children's chairs, one for the child and one for the examiner (Ayres, 2004, p12). If a translator is used during testing, a chair is provided for her too. The SIPT test administration ranges from 1½ to 2 hours, if no translation is needed. If the child requires translation, this administration time is increased. A short break is scheduled for the child after the completion of the first Postrotary Nystagmus test, which allows them to walk around, stretch their legs, go to the toilet and refocus for the next part. If the child's concentration is not adequate to guarantee reliable results, the test administration can be split over two sessions with a longer break in between, with the only requirement being the tactile tests have to be completed one after the other with no breaks in between. This is due to the cumulative effects of tactile stimulation and the clinical significance thereof (Ayres, 2004, p1, 2, 11).

A description of the SIPT subtests, materials required, expectations placed to the child and skills measured, is represented in **Table 2.1, Section 2.2.2.1.** In addition to these 17 subtests, clinical observations of prone extension, supine flexion and ocular pursuits are assessed, determined to be adequate, slightly deficient or poor, and recorded on the front of the test booklet.

Each subtest in the SIPT is child friendly and is presented in a cheerful, game-like manner.
The results of the SIPT describe six possible dysfunctions. (Ayres, 2004, p131)
These are:
SIPT group 1: Low average bilateral integration and sequencing,
SIPT group 2: General sensory integrative dysfunction,
SIPT group 3: Visio and somatodyspraxia,
SIPT group 4: Low average sensory integration and praxis,
SIPT group 5: Dyspraxia on verbal command and
SIPT group 6: High average sensory integration and praxis.

A child may fall into none, one or more than one of these categories.

3.4.1.2 Sensory Profile

In addition to this test, the Sensory Profile, compiled by Winnie Dunn (1999) was used. This test is a professional measure of the child's sensory processing abilities and based on the child's behaviour to sensory experiences. It allows the examiner to profile the effect of sensory processing on the functional performance in daily life of the child. It consists of a 125 question profile, in which parents or primary caregivers report the frequency with which their child responds to various sensory experiences. It contributes to a comprehensive assessment of the child's performance when combined with other evaluations.

Information gathered on each child from the prescription and treatment records in their oncology treatment files are: gender, age, type and stage of cancer at diagnosis and treatment received. This information was gathered by the researcher and recorded on the research data sheet.

3.4.2 Reliability and validity of tests

3.4.2.1 Sensory Profile, Winnie Dunn

Internal consistency of the Sensory Profile is an indication of the extent to which items in each section measure a single construct. Cronbach's coefficient alpha for the various sections in the Sensory Profile measure .47 to .91. The content validity of the Sensory Profile was established during the development of the test by determining that the test sampled the full range of sensory processing behaviours exhibited by children, and that these items were placed appropriately within the various sections. Results indicated that 80% of the 155 therapists involved in the study agreed on the category placement on 63% of the items. New categories were developed for the remaining items. The convergent and discriminant validity of the Sensory Profile was examined by comparing scores with different functional tasks as measured by the School Function Assessment (Dunn, 1999).

3.4.2.2 SIPT

The construct validity of the SIPT was determined by doing factor analysis of the SIPT from several different populations, with and without diagnosed sensory integrative disorders and learning difficulties. Cluster analysis was also done to determine whether the test is able to accurately measure

and identify clinically significant groups of individuals. Independent research has provided evidence in support of the validity of the cluster analysis (Ayres, 2004, p171, 179).
The test-retest reliability of the SIPT was evaluated in a sample of 41 dysfunctional children and 10 normal children. Each child was tested twice, with an interval of 1 to 2 weeks between tests. The praxis tests showed the highest reliability, but the other tests are considered acceptable (Ayres, 2004, p209).

Interrater reliability coefficients ranged from .94 to .99 on the SIPT. The test has a high interrater reliability due to the intensive training involved before being allowed to administer the test (Ayres, 2004, p209).

3.4.3 Methodological and Measurement Errors

The paediatric cancer population used as the study group in the research were South African children treated at State funded paediatric oncology units in identified areas in South Africa. Children who were acutely ill or in acute pain were not assessed until they were in a better state of health due to the possible negative effect of their physical state on the test results. Data collection was done by the researcher and another therapist at Universitas Hospital.

In order to administer and score the test, one is required to undergo formal training in sensory integration and praxis theory and SIPT administration provided by an acknowledged body that adheres to international standards in their training of work based on Ayres Sensory Integration (Ayres, 2004, p2). In South Africa the South African Institute for Sensory Integration (SAISI) provides the training to occupational therapists.

There are clear guidelines in the test manual regarding the administration of each subtest, including the environment, structuring and method of execution, and the scoring criteria.
The raw scores obtained by a child in the test items are processed on a computer, by making use of the official scoring software. This method of the processing of scores is accurate, as invalid or incorrect scores are not accepted by the programme. The same tests were administered to all 39 members of the study population.

The test administration took place in a room in the Occupational Therapy Department, Paediatric Oncology Unit, or lodger mother's unit. This testing area was quiet, free from external distractions and had the necessary space, lighting and furniture as specified in the test administration.

The administration of the SIPT took between two and six hours. Children were given a break, and in many cases testing was continued the following day, to allow the child to rest. The testing requirements of administering the tactile tests consecutively and without a break were adhered to due to the cumulative loading of the tactile sensations on the nervous system and the clinical significance of this (these tests include manual form perception, kinaesthesia, finger identification, graphesthesia and localisation of tactile stimuli). In a few cases, a short break had to be given in the administration of these tests as the children needed to defecate. This was recorded in the behavioural response to testing. Children were not forced to continue with the test if they became distressed during its administration.

A translator, proficient in English as well as the child's home language was present for the evaluations if the child was not proficient in English or

Afrikaans. This ensured that the child was evaluated in a language in which he was comfortable and had an adequate understanding of and that he understood the test instructions.

Available children diagnosed with and receiving treatment for childhood cancer (excluding primary central nervous system tumours or amputations) falling in the four (4-0) to eight year (8-11) age group were included in the study population as this is the age group on which the Sensory Integration and Praxis Tests (1989) was standardised.

Exclusion criteria were identified to ensure that accurate data was collected. These exclusion criteria were based on the possibility of skewed results being obtained or incomplete data sets due to the child not being able to participate in all subtests.

The SIPT has been standardised on an American Population comprising of children from various socio-economic and cultural backgrounds. In a study done by Van Jaarsveld, Mailloux and Herzberg (submitted for publication) on the use of the SIPT with South African children it was found that 12 of the 17 test items of the SIPT can be scored against the normative sample of the US children. On five test (DC, BMC, OPr, SWB and MAc) items within the older age bands (6y 0m – 8y 11m) the SA sample of children did perform moderately to significantly better than the US sample and that can cause children who do have sensory integration dysfunctions to go unidentified by the SIPT. For purposes of this research it was decided not to adapt any scores as a final decision on adaptation of scores for South African children has not been published.

Data was couriered to the biostatistician, where it was captured and analysed.

3.5 PILOT STUDY

A pilot study was undertaken at Universitas Hospital to determine if any adjustments had to be made to the research design. The data collected from this study was included in the data for the study population as there were no changes that had to be made to the research design, data sheet or informed consent.

3.6 DATA ANALYSIS

Descriptive statistics, namely means and standard deviations or medians and percentiles for continuous data and frequencies and percentages for categorical data, were calculated per type of sensory integrative disorder.

Descriptive statistics were used as the study was non-experimental, cross sectional and descriptive in design. No control group was present with which to compare the results of the sample group (Bailey, 1997, p122). Frequencies and percentages of the characteristics studied were represented for demographic information, chemotherapy administration method, handedness and behavioural responses to testing. Minimum, median and maximum scores in SIPT subtests were given and represented in each of the most commonly administered chemotherapy agents. SIPT scores for all subtests were given in standard deviations, as well as predetermined bands of severity of dysfunction or levels of advanced function and these were analysed and discussed in light of specific sensory integrative disorders as well as chemotherapy received.

3.7 SUMMARY

A sample of the childhood cancer population in South Africa was obtained by convenience sampling in three paediatric oncology units. The members of the study population were chosen based on predetermined inclusion and exclusion criteria **(Section 3.3.1).** Assessment tools used were the SIPT and the Sensory Profile. Information from the SIPT testing booklet and medical files were transcribed onto a data sheet **(Appendix 4).** These sheets were couriered to the biostatistician at the University of the Free State for analysis. Descriptive statistics were calculated, and described in terms of means, frequencies and percentages.

CHAPTER 4

-RESULTS-

4.1 INTRODUCTION

The aim of the study was to examine the prevalence of Sensory Integrative disorders among the childhood cancer population. Results are described using tables, graphs and a short description in the following order: characteristics of the study population, Sensory Integration and Praxis Tests (SIPT) scores, behavioural response to testing, clinical observations, administration method chemotherapy, chemotherapy received, and the results of the Sensory Profile. In conclusion there is a short summary.

4.2 CHARACTERISTICS OF THE STUDY POPULATION

A total of 39 children with cancer were included in the study. The greatest number of these (n=23), 59% were diagnosed with leukaemia/lymphoma and the other 16 (41%) with solid tumours **(cf. Figure 4.1).** The gender division was almost equal, with 19 members of the population (49%) being males, and the other 20 (51%) female **(cf. Figure 4.2).**

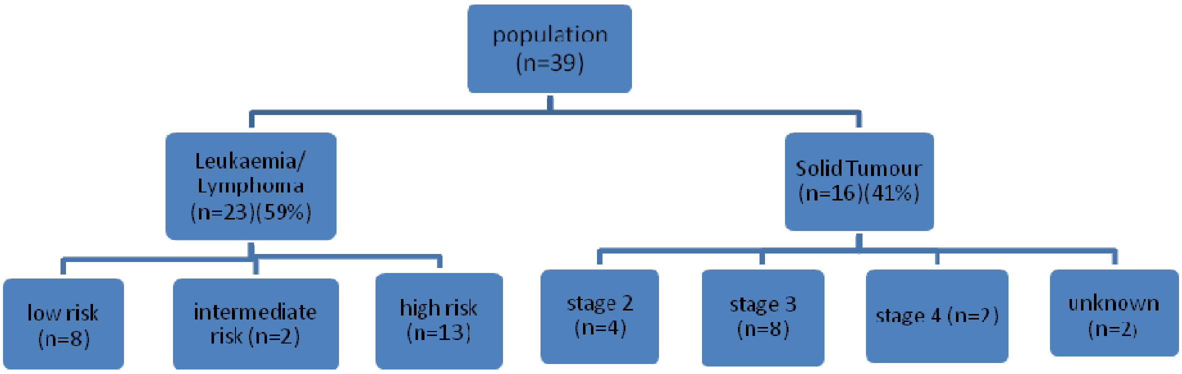


Figure 4.1 Characteristics of the Study Population (type of cancer and stage)

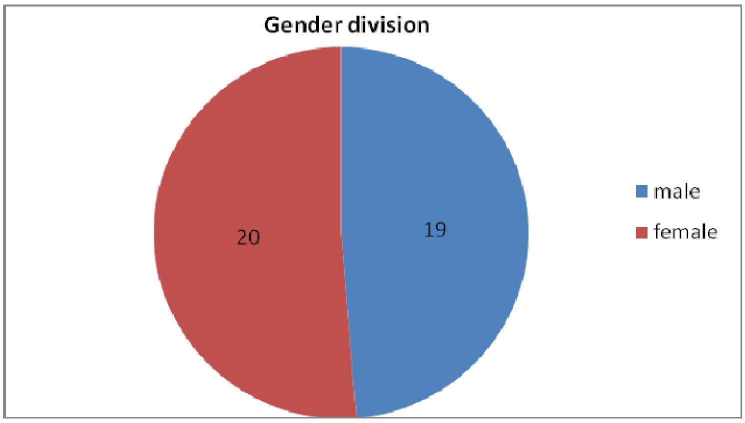


Figure 4.2 Gender division of study population

At the time of testing with the SIPT, the members of the study population were aged between 4y1m and 8y9m, with the median age being 6y4m **(cf. Table 4.1).** This is in keeping with the guidelines for use of the SIPT (Ayres, 2004, p1).

Table 4.1 Age of members of the study population (years)

	Minimum	Lower quartile	Median	Upper quartile	Maximum
Age	4.1	5.7	6.4	7.8	8.9

At the time of data collection, the mean time since diagnosis was 171 days **(cf. Table 4.2).**

Table 4.2 Time since diagnosis (days)

	Minimum	Lower quartile	Median	Upper quartile	Maximum
Time since diagnosis	11	79	171	367	2326

When analysing stage and risk, in the leukaemia/lymphoma group 8 members of the study population were determined to be low risk, 2 members of the study population intermediate risk and 13 members of the study population high risk. In the solid tumour group, 4 members of the study population were determined to have stage 2 disease, 8 members of the study population had stage 3 disease and 2 members of the study population had stage 4 disease. The staging information of two of the members of the study population could not be found **(cf. Figure 4.1).**

All the members of the study population had been attending school prior to diagnosis, and were considered to be in the grade specified. Most the members of the study population (22) were in preschool or crèche **(cf. Table 4.3).**

Table 4.3 Level of schooling at time of testing

	Preschool/ crèche	Grade 0	Grade 1	Grade 2	Grade 3
School grade	22	1	5	7	4

There was a spread in ethnicity representative of the patients making use of State funded hospitals in South Africa, with the majority of the study population being black children **(cf. Table 4.4).**

Table 4.4 Ethnicity of study population

	White	Black	Coloured	Asian	Indian
Ethnicity	3	32	1	0	3

The members of the study population's home languages were mostly one of the African dialects, with South Sotho (9), North Sotho (10) and Zulu (11) being the most widely spoken. There was one child who spoke Venda at home, 4 who were English speaking and 3 Afrikaans children **(cf. Table 4.5).**

Table 4.5 Home language of study population

	English	Afrikaans	South Sotho	North Sotho	Zulu	Xhosa	Other
Home language	4	3	9	10	11	1	1

The study population comprised of a variety of childhood cancer diagnoses, with ALL, AML and Wilm's tumour being the most common. Brain Tumours and tumours which had involved loss of both eyes or amputation of a limb were excluded to allow for participation in the SIPT (see discussion in **Section 3.3.1) (cf. Table 4.6).**

Table 4.6 Primary Cancer Diagnosis

Type of cancer	Number
Neuroblastoma	1 (3%)
Wilm's tumour	7 (18%)
Rhabdomyosarcoma	2 (5%)
Osteosarcoma	2 (5%)
Retinoblastoma	1 (3%)
Acute Lymphoblastic Leukemia (ALL)	11 (28%)
Acute Myeloid Leukemia (AML)	7 (18%)
Hodgkin's Lymphoma	1 (3%)
Non-Hodgkin's Lymphoma	3 (8%)
Other	4 (10%)

4.3 SIPT SCORES

The SIPT scores are shown in Standard Deviations (SD), or z-scores. These scores correspond to a metric associated with the normal curve. The normal distribution has an average SD or z-score of 0 and a standard deviation of 1. SD scores of -3.0 to -2.5 are indicative of a severe dysfunction. A SD of -2.5 to -2.0 is indicative of a definite dysfunction while a SD of -2.0 to -1.0 indicates a mild dysfunction. SD scores in the -1.0 to +1.0 range are considered indicative of typical functioning. Above average functioning for the child's age is indicated by scores +1.0 - +2.0 while advanced functioning receives scores +2.0 to +3.0. Scores equal to or below -3.0 are indicated as -3.0 and scores equal to or above +3.0 are indicated as +3.0 (Ayres, 2004, p115). The PRN score however is uniquely challenging in its interpretation, as a high (+1.0 and above) and low (less than -1.0) z-score or SD indicates a dysfunction (Mailloux *et al*, 2011, p144).

Table 4.7 indicates the SD of all subtests of the SIPT for all participants. Scores in the dysfunctional range have been highlighted in pink. Missing scores, due to the child refusing to participate in the subtest, or the subtest being discontinued due to a severe negative reaction on the child's part, including crying, running away, hitting the examiner or entering a state of "shut down" or severe distress, are indicated by an asterix (*) and highlighted peach. Tests which received scores indicating advanced functioning have been highlighted green.

Table 4.7 All SIPT subtest scores (SD) for study population

Child	SV	FG	DC	CPr	MAc	FI	LTS	MFP	GRA	BMC	PPr	SPr	OPr	PrVC	KIN	SWB	PRN
1	-0.91	0.76	-2.56	-3.00	-0.14	1.49	-0.70	-2.47	-1.17	-1.10	0.92	-0.72	1.16	-1.11	-1.88	-0.02	-2.35
2	-0.10	-1.26	-1.17	-0.93	-0.13	1.21	-0.75	-1.76	0.19	0.66	-0.20	-1.41	1.60	-0.39	-3.00	0.32	-1.01
3	-0.78	0.24	-1.25	-0.06	-2.28	-0.01	2.14	-1.59	-2.24	0.55	0.28	-0.03	1.51	-2.98	-1.05	0.71	-1.68
4	-1.84	-2.77	-2.92	-2.73	1.35	-1.54	-0.08	-1.42	-2.12	-0.63	-1.68	-0.96	-0.75	-3.00	-3.00	-1.85	-1.09
5	-1.40	-2.12	-3.00	-1.44	-2.02	-2.70	-3.00	-3.00	-1.80	-1.77	-2.13	-0.64	-0.85	-3.00	-3.00	-2.79	-1.01
6	-1.30	-2.30	0.63	-1.69	2.75	-1.19	-1.99	-3.00	-1.90	0.13	0.06	-2.24	0.07	-2.96	-1.71	0.45	-0.76
7	0.56	-0.22	1.93	0.76	2.23	1.89	-1.26	0.54	-0.44	0.95	-0.18	0.05	-1.55	-0.84	1.20	0.60	-0.78
8	-0.56	-0.54	-0.91	-0.74	-0.41	-1.54	-0.61	-2.93	-0.72	-0.30	-1.29	-1.38	-0.68	-1.98	-1.63	-1.24	0.15
9	0.83	1.28	0.65	1.34	2.04	0.42	1.02	-0.35	-0.60	2.23	-0.70	1.50	0.64	-1.56	-0.47	-0.11	-2.01
10	-1.51	-0.81	-3.00	-1.01	-2.81	-2.20	-3.00	-2.94	-1.16	-0.86	-1.82	-2.85	-1.38	-3.00	0.10	-1.61	-1.70
11	-3.00	-2.41	-2.89	-3.00	*	*	*	-3.00	*	-0.91	-2.21	-2.64	-2.01	-3.00	*	-2.04	0.01
12	-1.62	-1.80	-3.00	-2.28	*	-3.00	-2.42	-3.00	-2.48	-1.85	-2.32	-2.88	-1.59	-1.65	-3.00	-0.71	-1.95
13	-1.78	-2.70	-3.00	-2.24	-2.46	-1.33	-2.13	-3.00	-1.54	-2.04	-3.00	-1.41	-1.55	-3.00	-1.35	-3.00	-1.01
14	-0.87	-1.02	-3.00	-0.80	-2.77	0.96	2.55	-0.12	0.33	2.37	-0.40	1.03	1.34	-1.31	0.73	2.65	-1.14
15	-2.34	-1.53	-3.00	-2.41	-1.53	-3.00	-3.00	-3.00	-2.47	-0.91	-2.85	-1.78	-0.52	-3.00	-3.00	-3.00	0.63
16	-1.02	-2.32	-2.89	-0.90	-0.42	-1.27	-1.92	-3.00	-1.40	0.35	0.03	-0.69	-0.21	-3.00	-3.00	-0.04	-1.55
17	-3.00	-1.51	-3.00	-0.89	-1.83	-1.54	-3.00	-1.80	-1.60	-0.27	-1.90	-1.15	-1.35	-2.14	-1.92	-0.35	-1.40
18	-1.80	0.27	1.19	-0.56	0.97	-0.93	1.84	-1.32	-0.44	0.35	-1.79	-1.03	-0.60	-0.84	1.32	1.01	-0.48
19	-1.16	-1.76	-2.48	-1.89	-2.74	-1.09	-1.75	-2.51	-1.91	-1.52	-1.58	-2.62	-0.07	-3.00	-3.00	-0.88	-1.82
20	-1.46	-1.16	-2.75	-1.46	-0.82	2.02	-0.07	-2.71	-0.73	-0.52	-0.03	-1.30	0.20	-3.00	-3.00	0.09	-1.51
21	-0.62	-0.49	-0.97	-0.68	1.61	-0.79	-1.97	-0.24	-2.40	1.70	-0.21	-1.22	-0.61	-3.00	-1.84	0.02	-1.16
22	-2.28	-2.39	-2.19	-1.06	-1.18	-3.00	-3.00	-1.65	-1.60	-1.42	-0.67	-1.89	-2.19	-2.35	*	-0.40	-1.04
23	-1.50	-2.31	-3.00	-1.87	0.14	-2.11	-1.12	-3.00	-0.74	-1.54	-2.21	-2.07	0.01	-2.96	-1.75	-1.93	-0.10
24	-1.60	-1.62	-2.41	-2.03	0.94	-0.39	1.61	-0.66	-2.40	-1.44	-2.91	-2.56	-0.38	-3.00	0.96	0.50	1.44

Child	SV	FG	DC	CPr	MAc	FI	LTS	MFP	GRA	BMC	PPr	SPr	OPr	PrVC	KIN	SWB	PRN
25	0.51	-0.23	0.67	-0.17	-1.32	0.45	-0.15	-3.00	-1.25	1.04	-1.68	-0.41	0.35	-3.00	-0.81	-2.77	-1.37
26	-1.39	0.80	-0.19	0.60	-2.25	0.63	0.59	-1.15	-0.09	1.91	-0.29	-0.40	-0.70	-3.00	0.53	-3.00	-1.04
27	-0.66	-1.25	-1.67	-1.36	1.02	-0.71	1.00	-2.51	-1.47	-0.22	-1.14	-0.47	0.82	-3.00	-2.68	0.72	0.77
28	-1.52	-1.53	-2.87	-2.02	-2.30	-0.94	-0.77	-2.18	-0.74	-1.70	-2.64	-1.55	-1.95	-2.96	-1.13	-1.21	-2.08
29	-0.18	-1.85	-3.00	-0.53	-2.66	-1.25	0.55	-1.53	-3.00	-1.02	-3.00	-2.79	0.11	-3.00	-2.45	-1.02	-0.17
30	-0.73	-1.58	-1.52	-0.54	-0.88	-0.35	-0.63	0.64	-0.92	-1.68	-1.08	-0.65	-0.24	0.39	-3.00	0.75	-1.08
31	-1.60	-1.40	-3.00	-2.33	-3.00	0.00	0.95	-3.00	-1.66	-1.79	-2.10	-3.00	-2.62	-3.00	-1.00	-0.42	-2.21
32	-1.62	-0.91	-0.06	0.53	0.65	-0.64	-1.35	-3.00	-2.74	-0.33	0.92	-1.00	-2.38	-3.00	0.44	-3.00	-0.37
33	-1.87	-1.63	-1.31	-0.35	2.58	-1.67	-0.03	-1.10	-0.68	0.93	-0.37	-0.23	-0.35	-3.00	-0.19	0.82	-1.49
34	-1.34	-1.85	0.95	0.16	-2.93	0.80	0.15	1.05	-2.15	0.65	-0.48	-0.34	-0.16	-3.00	0.19	-1.07	-2.07
35	-2.08	-0.77	-2.30	-1.58	-2.24	-2.57	*	-0.50	-1.37	-0.61	-1.69	-0.40	0.83	-3.00	*	-1.65	-0.91
36	-2.94	-2.30	-2.44	-1.24	-1.14	-0.83	-3.00	-2.39	-1.68	-1.18	-3.00	-2.53	-2.92	-3.00	-2.65	0.55	0.95
37	-2.58	0.53	-0.72	-1.26	-1.01	-0.74	-2.21	-3.00	-1.03	-0.48	-1.24	-0.24	-1.11	-3.00	-2.36	0.32	0.36
38	-2.58	-0.71	0.93	1.66	0.83	0.53	-3.00	0.37	0.19	1.99	0.21	-0.11	-0.36	-0.87	0.01	1.01	0.70
39	0.09	-1.33	-1.02	-0.17	-2.37	1.53	-0.90	-0.24	-1.15	0.20	-0.88	-0.21	1.26	-3.00	-1.12	1.29	-0.80

(SV= Space Visualisation, FG= Figure Ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= Graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= Kinaesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

Table 4.8 Standard Deviation (SD) score ranges for all SIPT subtests

	SV n=39	FG n=39	MFP n=39	KIN n=36	FI n=38	GRA n=38	LTS n=38	PrVC n=39	DC n=39	CPr n=39	PPr n=39	OPr n=39	SPr n=39	BMC n=39	SWB n=39	MAc n=37	PRN n=39
Severe Dysfunction -3.0 SD to-2.5 SD	5	2	17*	11*	5	2	7	27*	16*	3	6	2	8	0	6	6	0
Definite Dysfunction -2.5 SD to -2.0 SD	3	7	3	2	2	7	3	2	5	6	5	3	2	1	1	7	5
Mild Dysfunction -2.0 SD to -1.0SD	18*	16*	9	10	9	16*	7	5	6	11*	11*	7	10	12*	8	6	18*
Typical Performance -1.0 SD to +1.0 SD	13*	13*	9	11*	17*	13*	15*	5	10	17*	17*	22*	17*	20*	20*	11*	15*
Above Average Function +1.0 SD to +2.0 SD	0	1	1	2	4	0	4	0	2	2	0	5	2	4	3	3	1
Advanced Function +2.0 SD to +3.0 SD	0	0	0	0	1	0	2	0	0	0	0	0	0	2	1	4	0

(SV= Space Visualisation, FG= Figure Ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= Graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= Kinaesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

* More than one quarter (25%) of the study population

NUMBERS IN CELLS REFER TO NUMBERS OF CHILDREN

In **Table 4.8**, the distribution of these scores in the SD ranges indicating levels of function and dysfunction are shown. The numbers of individuals scoring subtests in the ranges of function and dysfunction are indicated, (as clarified in **Section 2.3,** paragraph 1). Missing test scores have been excluded in this table. It can be seen from this table that the majority of test scores were in the dysfunctional range, with varying levels of severity. There were some tests in which the members of the study population showed advanced functioning, specifically in MAc, BMC, FI and LTS. There were four (4) members of the study population who had advanced functioning in performance of the MAc test. The highest prevalence of scores in the severely dysfunctional range was seen in percentages of the population in PrVC (n=27, 69%), MFP (n=17, 44%), DC (n=16, 41%) and KIN (n=11, 31%). Scores in the mildly dysfunctional range were obtained in PRN (n=18, 46%), SV (n=18, 46%), FG (n=16, 41%), GRA (n=13, 34%), BMC (n=12, 328%), 1%), CPr (n=11, 28%), and PPr (n=11, 28%). The population percentages obtaining scores in the typical range are : Opr (n=22, 56%), BMC(n=20,51%), SWB(n=20, 51%), CPr(n=17,44%), FI(n=17,44%), PPr(n=17, 44%), SPr(n=17, 44%), LTS(n=15, 39%), PRN(n=15, 38%), SV(n=13, 33%), FG(n=13, 33%), GRA(n=13, 34%), KIN(n=11, 31%) and MAc(n=11, 30%).

Table 4.9 SD score ranges (minimum, median, maximum and mean) of all SIPT subtests

	Minimum	Median	Maximum	Mean
SV	-3.00	-1.46	0.83	-1.31
FG	-2.77	-1.40	1.28	-1.91
DC	-3.00	-2.30	1.93	-1.6
CPr	-3.00	-1.01	1.66	-1.03
MAc	-3.00	-1.01	2.75	-0.72
FI	-3.00	-0.81	2.02	-0.67
LTS	-3.00	-0.77	2.55	-0.85
MFP	-3.00	-2.18	1.05	-1.78
GRA	-3.00	-1.38	0.33	-1.34
BMC	-2.04	-0.48	2.37	-0.26
PPr	-3.00	-1.24	0.92	-1.21
SPr	-3.00	-1.03	1.50	-1.16
OPr	-2.92	-0.38	1.60	-0.49
PrVC	-3.00	-3.00	0.39	-2.45
KIN	-3.00	-1.67	1.32	-1.37
SWB	-3.00	-0.35	2.65	-0.57
PRN	-2.35	-1.04	1.44	-0.87

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= Kinaesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

The distribution of scores (minimum, median and maximum) of all subtests in the SIPT is shown in **Table 4.9**. There were a number of subtests where the performance across the study population was in the dysfunctional range, with mean scores for the subtests in the below average range. Four of the five tests of form and space perception (SV, FG, DC, CPr) had mean scores in the mild dysfunctional range. Other mean scores in the mild dysfunctional range were MFP, GRA, PPr, SPr, and KIN. The mean score for PrVC was in the definite dysfunction range. This indicates that in more than half the SIPT subtests (10/17) the mean score over the study population was in the mild dysfunctional range.

4.3.1 Analysis of SIPT scores in areas of function

The areas of function have been determined by the four primary domains that the SIPT assesses, and into which the tests can be divided. These are: Form and space, visual-motor coordination, construction (SV, FG, DC, CPr, MAc); Praxis (BMC, SPR, PPr, OPr, PrVC); Tactile discrimination (FI, LTS, MFP, GRA); and Vestibular and proprioceptive processing (KIN, SWB, PRN) (Bundy *et al*, 2002, p172: Adapted from Ayres).

4.3.1.1 Form and Space Perception, Visual Motor Coordination and Visual Construction

Form and Space perception, Visual Motor Coordination and Visual Construction is the first domain into which the SIPT subtests can be roughly divided (Bundy *et al*, 2002, p172: Adapted from Ayres). Functioning here gives an idea of the child's ability to make sense of and use the two and three dimensional space in their environment, and their ability to write and draw.

Table 4.10 SD score ranges for tests of Form and Space Perception, Visual Motor Coordination and Visual Construction

Test	Severe Dysfunction -3.0 SD to-2.5 SD	Definite Dysfunction -2.5 SD to -2.0 SD	Mild Dysfunction -2.0 SD To - 1.0SD	Typical Performance -1.0 SD to +1.0 SD	Above Average +1.0 SD to +2.0 SD	Advanced Function +2.0 SD to +3.0 SD
SV (n=39)	5	3	18	13	0	0
FG (n=39)	2	7	16	13	1	0
DC (n=39)	16	5	6	10	2	0
CPr (n=39)	3	6	11	17	2	0
MAc (n=37)	6	7	6	11	3	4

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy).
NUMBERS IN CELLS REFER TO NUMBER OF CHILDREN

In tests of form and space perception, visual motor coordination and visual construction **(cf. Table 4.10),** 26 of 39 members of the study population (67%) tested in the dysfunctional range on SV. Of these members of the study population, 18 (46%) were in the mild dysfunction level, 3 (8%) had a definite dysfunction and 5 (13%) had a severe dysfunction in SV. Dysfunctional range scores in FG were obtained in 25 members of the study population (64%), with 16 (41%) of these being mildly dysfunctional, 7 (18%) having a definite dysfunction and 2 (5%) with a severe dysfunction. DC had the highest incidence of severe dysfunction, with 16(41%) of members of the study population scoring in this range. Scores indicating definite and mild dysfunctions were seen in 5 (13%) and 6 (15%) of members of the study population respectively in DC, resulting in 27members of the study population (69%) of members of the study population testing in the dysfunctional range. CPr scores showed 20 (51%) in the dysfunctional range, with most of these (n=11/39; 28%) being mild dysfunctions. Just over half, (n=19/37, 51%) of members of the study population tested had difficulty with MAc, however 4 members of the study population (11%) who received scores indicative of advanced function in this test. Two members of the study population refused to complete the test and became very anxious and tearful at the prospect. The scores for these two members of the study population are reported missing.

Typical functioning for age was seen in 13 (33%) members of the study population with SV and FG tests, 10 (26%) members of the study population with DC tests, 17 (44%) members of the study population with CPr and 11 (30%) members of the study population with MAc tests.

Most the scores from the subtests which assessed form and space perception, visual motor coordination and visual construction were determined to be in the dysfunctional range.

Table 4.11 Design Copying errors made (n=32)

Error	Severe Dysfunction -3.0 SD to -2.5 SD	Definite Dysfunction -2.5 SD to -2.0 SD	Mild Dysfunction -2.0 SD to -1.0 SD	Typical Performance -1.0 SD to +1.0 SD	Above Average +1.0 SD to +2.0 SD	Advanced Function +2.0 SD to +3.0 SD
Boundaries	0	0	2 (6%)	20 (63%)	10 (31%)	0
Additions	1 (3%)	1 (3%)	3 (9%)	27 (85%)	0	0
Segmentations	3 (9%)	2 (6%)	9 (28%)	11 (35%)	7 (22%)	0
Reversals	0	2 (6%)	3 (9%)	27 (85%)	0	0
Right to left	0	1 (3%)	1 (3%)	21 (66%)	9 (28%)	0
Inversion	0	0	4 (13%)	28 (87%)	0	0
Jogs	2 (6%)	3 (9%)	1 (3%)	26 (82%)	0	0
Distortions	0	3 (9%)	4 (13%)	24 (75%)	1 (3%)	0

Design copying errors, represented in **Table 4.11**, are atypical approaches made by the child in replicating the stimulus. A description of the errors is in the list of definitions. DC errors are only examined in members of the study population over the age of four years (Ayres, 2004, p45). The presence of more atypical approaches are indicative of visuodyspraxia (Ayres, 2004, p137). In the above table it can be noted that a high percentage of members of the study population had a typical approach to reproducing the two-dimensional line drawings in the test, with errors in boundaries (63%), additions (85%), reversals (85%), right to left (66%), inversion (87%), jogs (82%) and distortions (75%) performing typically. There were some members of the study population who seemed to have advanced visuopractic abilities, noted in the above average scores in boundaries (31%), segmentations (22%), right to left (28%) and distortions (3%) obtained. Dysfunctional performance was noted in a smaller percentage of members of the study population, with atypical approaches noted in segmentations (43%), distortions (22%), jogs (18%), reversals (15%), additions (15%), inversions (13%), right to left (6%) and boundaries (6%).

Table4.12 Constructional Praxis errors made (n=32)

Parameter	Severe Dysfunction -3.0 SD to - 2.5 SD	Definite Dysfunction -2.5 SD to - 2.0 SD	Mild Dysfunction -2.0 SD to -1.0 SD	Typical Performance -1.0 SD to +1.0 SD	Above Average +1.0 SD to +2.0 SD	Advanced Function +2.0 SD to +3.0 SD
Displacement 1-2.5cm	1 (3%)	1 (3%)	4 (13%)	10 (31%)	16 (50%)	0
Displacement >2.5cm	0	0	2 (6%)	18 (56%)	12 (38%)	0
Rotation >15 Degrees	2 (6%)	0	2 (6%)	16 (50%)	12 (38%)	0
Reversals	0	0	1 (3%)	21 (66%)	10 (31%)	0
Incorrect but Logical	0	1 (3%)	1 (3%)	30 (94%)	0	0
Gross Mislocation	9 (28%)	0	1 (3%)	22 (69%)	0	0
Omission (n=29)	8 (28%)	0	4 (14%)	17 (58%)	0	0

Constructional praxis errors are made when incorrect blocks are used or when blocks are placed incorrectly in the child's attempt to replicate the three dimensional model in CPr part 2. They are only examined in members of the study population above the age of four years (Ayres, 2004, p68). A description of the parameters is in the list of definitions. A large portion of members of the study population approached this task with a performance and skill level typical of their age in displacement 1 to 2,5cm (31%), displacement more than 2,5cm (56%), rotation greater than 15 degrees (50%), reversals (66%), incorrect but logical (94%), gross mislocation (94%), and omissions (58%). Above average functioning was present in displacement 1 to 2,5cm (50%), displacement more than 2,5cm (38%), rotation greater than 15 degrees (38%), and reversals (31%). There were members of the study population who experienced difficulty manipulating the blocks into the correct position in three dimensional space, with scores in the dysfunctional ranges being obtained in parameters of displacement 1 to 2,5cm (19%), displacement more than 2,5cm (6%), incorrect but logical (3%), gross mislocation (28%) and omission (28%).

4.3.1.2 Praxis

Praxis is the domain that SIPT tests assessing motor planning ability are included in. These tests are an indication of the child's ability to plan and execute movement sequences in his own body based on a visual demonstration or a verbal instruction given by the examiner (Bundy *et al*, 2002 ,p172, Adapted from Ayres,1989).

Table 4.13 SD score ranges for tests of Praxis

Test	Severe Dysfunction -3.0 SD to-2.5 SD	Definite Dysfunction -2.5 SD to -2.0 SD	Mild Dysfunction -2.0 SD to -1.0SD	Typical Performance -1.0 SD to +1.0 SD	Above Average +1.0 SD to +2.0 SD	Advanced Function +2.0 SD to +3.0 SD
BMC (n=39)	0	1 (3%)	12 (31%)	20 (51%)	4 (10%)	2 (5%)
SPR (n=39)	8 (21%)	2 (5%)	10 (26%)	17 (44%)	2 (5%)	0
PPr (n=39)	6 (15%)	5 (13%)	11 (28%)	17 (44%)	0	0
OPr (n=39)	2 (5%)	3 (8%)	7 (18%)	22 (56%)	5 (13%)	0
PrVC (n=39)	27 (69%)	2 (5%)	5 (13%)	5 (13%)	0	0

(BMC= Bilateral Motor Coordination, SPr= Sequencing Praxis, PPr = Postural Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command)

In the Praxis subtests **(cf Table 4.13)**, there was a generally strong performance on BMC, with 20 (51%) of members of the study population receiving scores indicative of typical functioning for their age and 13 (33%) performing with a degree of dysfunction. Almost half, (51%) of the members of the study population had varying degrees of dysfunction in SPr respectively, whilst 17 (44%) of these members of the study population performed typically. PPr performance in 22 (56%) of members of the study population was indicative of a dysfunction, whilst 17 (44%) of these members of the study population performed adequately for their age. OPr performance was generally strong, with the majority of members of the study population (56%) performing typically for their age. PrVC scores were indicative of a severe dysfunction in 27 (69%).

The scores on the praxis tests were spread relatively evenly between a group of individuals with dysfunction and those that are typically functioning, with OPr being a test where many of the members of the study population performed typically or above average, and PrVC being a test where the majority of members of the study population experienced significant difficulty.

4.3.1.3 Tactile Discrimination

Tactile discrimination tests are a domain of functioning that SIPT scores are roughly divided into. This domain consists of tests assessing the child's ability to accurately process tactile information from his hands and forearms without visual assistance to determine where and how he is touched (Bundy *et al*, 2002 p172, Adapted from Ayres ,1989).

Table 4.14 SD score ranges for Tactile Discrimination

Test	Severe Dysfunction -3.0 SD to-2.5 SD	Definite Dysfunction -2.5 SD to -2.0 SD	Mild Dysfunction -2.0 SD to -1.0SD	Typical Performance -1.0 SD to +1.0 SD	Above Average +1.0 SD to +2.0 SD	Advanced Function +2.0 SD to +3.0 SD
FI (n=38)	5 (13%)	2 (5%)	9 (24%)	17 (45%)	4 (10%)	1 (3%)
LTS (n=37)	7 (19%)	3 (8%)	7 (19%)	14 (38%)	4 (11%)	2 (5%)
MFP (n=39)	17 (44%)	3 (8%)	9 (23%)	9 (23%)	1 (3%)	0
GRA (n=38)	2 (5%)	7 (18%)	16 (42%)	13 (34%)	0	0

(FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= Graphesthesia)

Scores for tests of tactile discrimination are given in **Table 4.14.** FI and LTS had the greater percentage of typically performance and above average performance members of the study population, with 22 (58%) and 20 (54%) members of the study population respectively receiving scores indicative of this. There was one child who refused to participate in the FI test and two members of the study population who refused LTS; these scores are thus missing.

MFP and GRA had a greater percentage of members of the study population scoring in the dysfunctional range, with 29 (74%) and 25 (66%) respectively scoring in various levels of dysfunction. MFP was particularly challenging for the members of the study population, with 17 (%) scoring in a range indicative of severe dysfunction.

The above average and advanced functioning scores on LTS (n=6/37; 16%) is notable in terms of the possible loading of tactile input to the central nervous system in a child with tactile hypersensitivities.

4.3.1.4 Vestibular and Proprioceptive Processing

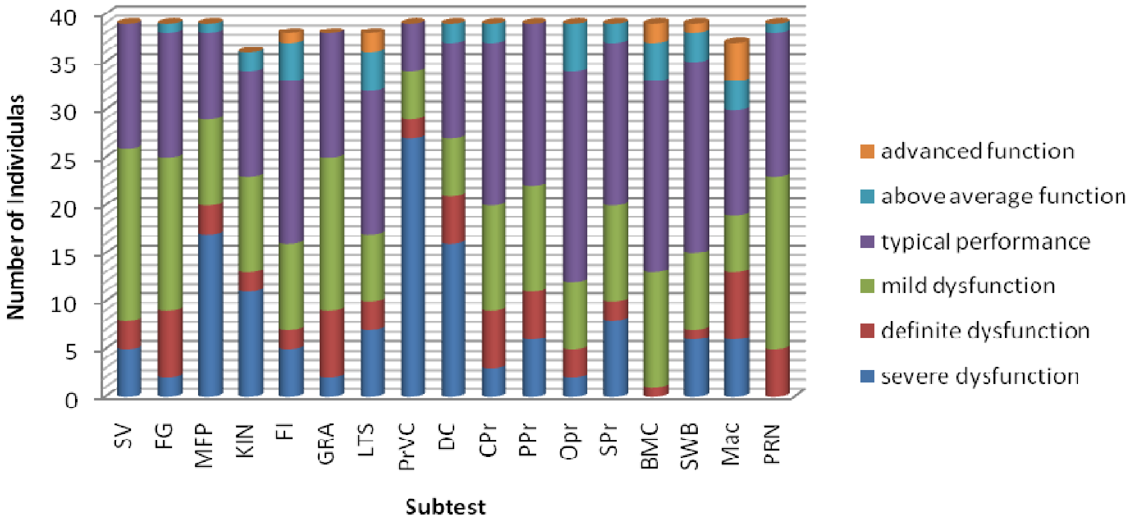
Tests if vestibular and proprioceptive functioning are grouped together in a separate domain functioning in the SIPT . These tests provide information about the child's ability to process vestibular and proprioceptive information and central nervous system integrity (Bundy *et al*, 2002 p172, Adapted from Ayres ,1989)

Table 4.15 SD score ranges for tests of Vestibular and Proprioceptive Processing

Test	Severe Dysfunction -3.0 SD to-2.5 SD	Definite Dysfunction -2.5 SD to -2.0 SD	Mild Dysfunction -2.0 SD to -1.0SD	Typical Performance -1.0 SD to +1.0 SD	Above Average +1.0 SD to +2.0 SD	Advanced Function +2.0 SD to +3.0 SD
KIN (n=36)	11 (31%)	2 (5%)	10 (28%)	11 (31%)	2 (5%)	0
SWB (n=39)	6 (15%)	1 (3%)	8 (21%)	20 (51%)	3 (8%)	1 (3%)
PRN (n=39)	0	5 (13%)	18 (46%)	15 (38%)	1 (3%)	0

(KIN= Kinaesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

Table 4.15 represents information on tests of vestibular and proprioceptive processing**.** There was an increased prevalence of KIN scores dysfunctional ranges, with 11 (31%) of members of the study population testing in the severe dysfunctional range, and a further 2 (6%) and 10 (28%) with scores indicative of a definite and mild dysfunction respectively. 11 (31%) of members of the study population were typical in their performance in KIN. There was a markedly typical performance in SWB, in contrast to other scores achieved. 20 (51%) of members of the study population had typical standing and walking balance abilities. The majority of members of the study population had a PRN in the mildly dysfunctional range (n=18/39; 46%) or the typical performance range (n=15/39; 38%). There was one child who tested with PRN in the above average range. As reported in **Section** 4.3 paragraph 1, a PRN score in the above average range is also indicative of a dysfunction.



(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= Kinaesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

Figure 4.3 SD score ranges of all individuals for all subtests

SIPT subtest scores in the predetermined ranges of function and dysfunction are summarised in **Figure 4.3.** From this figure, it can be seen that there was an increased prevalence of scores in the dysfunctional ranges in SV, FG, MFP, KIN, GRA, PrVC, DC, PPr, and PRN. MAc, SPr and CPr were almost evenly distributed among members of the study population testing with typical or above average function, and those experiencing a level of dysfunction. Tests where there was an increased prevalence of typical and above average functioning include FI, LTS OPr BMC and SWB.

4.3.2 Analysis of SIPT scores according to predetermined diagnostic groups

There are six prototypic diagnostic groups that have been determined after standardisation and cluster analysis of the SIPT (Ayres, 2004, p131). These are:

SIPT group 1: Low Average Bilateral Integration and Sequencing
SIPT group 2: Generalised Sensory Integrative Disorder
SIPT group 3: Visuo- and Somatodyspraxia
SIPT group 4: Low Average Sensory Integration and Praxis
SIPT group 5: Dyspraxia on Verbal Command
SIPT group 6: High Average Sensory Integration and Praxis

Analysis of the SIPT scores of all members of the study population, and the patterns in which these scores occurred, led to the determination that the study population could be considered to have a degree of bilateral integration and sequencing dysfunction **(cf Table 4.16),** visuodyspraxia **(cf Table 4.17)** with or without somatodyspraxia, somatodyspraxia **(cf Table 4.18),** a generalised sensory integrative disorder **(cf Table 4.19)** or dyspraxia on verbal command **(cf Table 4.20).** These results have been tabulated and the scores indicating possible inclusion in the diagnostic group highlighted. No members of the study population were determined to be included in SIPT groups 1 or 6 (Low Average or High Average Sensory Integration and Praxis).

4.3.2.1 Low Average Bilateral Integration and Sequencing

A child who tests within this diagnostic group is considered to have low average bilateral integration and sequencing and is not considered to be dysfunctional. The child may score particularly well on some tests while others are within the normal range (Ayres, 2004, p140) However, when a child's scores low on OPr, SPr, BMC, SWB, GRA and possibly PPr are well below the other scores a child is considered to have a Bilateral Integration and Sequencing dysfunction. PrVC is typically one of the highest praxis scores within this group (Ayres. 2004, p144). **Table 4.16** shows 3 members of the study population who could be considered to have bilateral integration and sequencing difficulties. The highlighted scores were in contrast to most of the other scores. Although the remaining scores were not in the average range, and PrVC was not the highest scoring praxis test, **figure 4.3** indicates members of the study population who tested in dysfunctional ranges for the tests. Child 29, 32 and 36 had low scores in tests requiring the skilled use of both sides of the body, and these scores are in contrast with the other scores on the SIPT.

Three members of the study population in the study population (8%) presented with a pattern of scores which indicates difficulty in bilateral integration and sequencing.

Table 4.16 SIPT scores (SD) indicating possible Low Average Bilateral Integration and Sequencing in study population

Child	SV	FG	DC	CPr	MAc	FI	LTS	MFP	GRA	BMC	PPr	SPr	OPr	PrVC	KIN	SWB	PRN
1	-0.91	0.76	-2.56	-3.00	-0.14	1.49	-0.70	-2.47	-1.17	-1.10	0.92	-0.72	1.16	-1.11	-1.88	-0.02	-2.35
2	-0.10	-1.26	-1.17	-0.93	-0.13	1.21	-0.75	-1.76	0.19	0.66	-0.20	-1.41	1.60	-0.39	-3.00	0.32	-1.01
3	-0.78	0.24	-1.25	-0.06	-2.28	-0.01	2.14	-1.59	-2.24	0.55	0.28	-0.03	1.51	-2.98	-1.05	0.71	-1.68
4	-1.84	-2.77	-2.92	-2.73	1.35	-1.54	-0.08	-1.42	-2.12	-0.63	-1.68	-0.96	-0.75	-3.00	-3.00	-1.85	-1.09
5	-1.40	-2.12	-3.00	-1.44	-2.02	-2.70	-3.00	-3.00	-1.80	-1.77	-2.13	-0.64	-0.85	-3.00	-3.00	-2.79	-1.01
6	-1.30	-2.30	0.63	-1.69	2.75	-1.19	-1.99	-3.00	-1.90	0.13	0.06	-2.24	0.07	-2.96	-1.71	0.45	-0.76
7	0.56	-0.22	1.93	0.76	2.23	1.89	-1.26	0.54	-0.44	0.95	-0.18	0.05	-1.55	-0.84	1.20	0.60	-0.78
8	-0.56	-0.54	-0.91	-0.74	-0.41	-1.54	-0.61	-2.93	-0.72	-0.30	-1.29	-1.38	-0.68	-1.98	-1.63	-1.24	0.15
9	0.83	1.28	0.65	1.34	2.04	0.42	1.02	-0.35	-0.60	2.23	-0.70	1.50	0.64	-1.56	-0.47	-0.11	-2.01
10	-1.51	-0.81	-3.00	-1.01	-2.81	-2.20	-3.00	-2.94	-1.16	-0.86	-1.82	-2.85	-1.38	-3.00	0.10	-1.61	-1.70
11	-3.00	-2.41	-2.89	-3.00	*	*	*	-3.00	*	-0.91	-2.21	-2.64	-2.01	-3.00	*	-2.04	0.01
12	-1.62	-1.80	-3.00	-2.28	*	-3.00	-2.42	-3.00	-2.48	-1.85	-2.32	-2.88	-1.59	-1.65	-3.00	-0.71	-1.95
13	-1.78	-2.70	-3.00	-2.24	-2.46	-1.33	-2.13	-3.00	-1.54	-2.04	-3.00	-1.41	-1.55	-3.00	-1.35	-3.00	-1.01
14	-0.87	-1.02	-3.00	-0.80	-2.77	0.96	2.55	-0.12	0.33	2.37	-0.40	1.03	1.34	-1.31	0.73	2.65	-1.14
15	-2.34	-1.53	-3.00	-2.41	-1.53	-3.00	-3.00	-3.00	-2.47	-0.91	-2.85	-1.78	-0.52	-3.00	-3.00	-3.00	0.63
16	-1.02	-2.32	-2.89	-0.90	-0.42	-1.27	-1.92	-3.00	-1.40	0.35	0.03	-0.69	-0.21	-3.00	-3.00	-0.04	-1.55
17	-3.00	-1.51	-3.00	-0.89	-1.83	-1.54	-3.00	-1.80	-1.60	-0.27	-1.90	-1.15	-1.35	-2.14	-1.92	-0.35	-1.40
18	-1.80	0.27	1.19	-0.56	0.97	-0.93	1.84	-1.32	-0.44	0.35	-1.79	-1.03	-0.60	-0.84	1.32	1.01	-0.48
19	-1.16	-1.76	-2.48	-1.89	-2.74	-1.09	-1.75	-2.51	-1.91	-1.52	-1.58	-2.62	-0.07	-3.00	-3.00	-0.88	-1.82
20	-1.46	-1.16	-2.75	-1.46	-0.82	2.02	-0.07	-2.71	-0.73	-0.52	-0.03	-1.30	0.20	-3.00	-3.00	0.09	-1.51
21	-0.62	-0.49	-0.97	-0.68	1.61	-0.79	-1.97	-0.24	-2.40	1.70	-0.21	-1.22	-0.61	-3.00	-1.84	0.02	-1.16
22	-2.28	-2.39	-2.19	-1.06	-1.18	-3.00	-3.00	-1.65	-1.60	-1.42	-0.67	-1.89	-2.19	-2.35	*	-0.40	-1.04
23	-1.50	-2.31	-3.00	-1.87	0.14	-2.11	-1.12	-3.00	-0.74	-1.54	-2.21	-2.07	0.01	-2.96	-1.75	-1.93	-0.10
24	-1.60	-1.62	-2.41	-2.03	0.94	-0.39	1.61	-0.66	-2.40	-1.44	-2.91	-2.56	-0.38	-3.00	0.96	0.50	1.44
25	0.51	-0.23	0.67	-0.17	-1.32	0.45	-0.15	-3.00	-1.25	1.04	-1.68	-0.41	0.35	-3.00	-0.81	-2.77	-1.37
26	-1.39	0.80	-0.19	0.60	-2.25	0.63	0.59	-1.15	-0.09	1.91	-0.29	-0.40	-0.70	-3.00	0.53	-3.00	-1.04
27	-0.66	-1.25	-1.67	-1.36	1.02	-0.71	1.00	-2.51	-1.47	-0.22	-1.14	-0.47	0.82	-3.00	-2.68	0.72	0.77

Child	**SV**	**FG**	**DC**	**CPr**	**MAc**	**FI**	**LTS**	**MFP**	**GRA**	**BMC**	**PPr**	**SPr**	**OPr**	**PrVC**	**KIN**	**SWB**	**PRN**
28	-1.52	-1.53	-2.87	-2.02	-2.30	-0.94	-0.77	-2.18	-0.74	-1.70	-2.64	-1.55	-1.95	-2.96	-1.13	-1.21	-2.08
29	-0.18	-1.85	-3.00	-0.53	-2.66	-1.25	0.55	-1.53	-3.00	-1.02	-3.00	-2.79	0.11	-3.00	-2.45	-1.02	-0.17
30	-0.73	-1.58	-1.52	-0.54	-0.88	-0.35	-0.63	0.64	-0.92	-1.68	-1.08	-0.65	-0.24	0.39	-3.00	0.75	-1.08
31	-1.60	-1.40	-3.00	-2.33	-3.00	0.00	0.95	-3.00	-1.66	-1.79	-2.10	-3.00	-2.62	-3.00	-1.00	-0.42	-2.21
32	-1.62	-0.91	-0.06	0.53	0.65	-0.64	-1.35	-3.00	-2.74	-0.33	0.92	-1.00	-2.38	-3.00	0.44	-3.00	-0.37
33	-1.87	-1.63	-1.31	-0.35	2.58	-1.67	-0.03	-1.10	-0.68	0.93	-0.37	-0.23	-0.35	-3.00	-0.19	0.82	-1.49
34	-1.34	-1.85	0.95	0.16	-2.93	0.80	0.15	1.05	-2.15	0.65	-0.48	-0.34	-0.16	-3.00	0.19	-1.07	-2.07
35	-2.08	-0.77	-2.30	-1.58	-2.24	-2.57	*	-0.50	-1.37	-0.61	-1.69	-0.40	0.83	-3.00	*	-1.65	-0.91
36	-2.94	-2.30	-2.44	-1.24	-1.14	-0.83	-3.00	-2.39	-1.68	-1.18	-3.00	-2.53	-2.92	-3.00	-2.65	0.55	0.95
37	-2.58	0.53	-0.72	-1.26	-1.01	-0.74	-2.21	-3.00	-1.03	-0.48	-1.24	-0.24	-1.11	-3.00	-2.36	0.32	0.36
38	-2.58	-0.71	0.93	1.66	0.83	0.53	-3.00	0.37	0.19	1.99	0.21	-0.11	-0.36	-0.87	0.01	1.01	0.70
39	0.09	-1.33	-1.02	-0.17	-2.37	1.53	-0.90	-0.24	-1.15	0.20	-0.88	-0.21	1.26	-3.00	-1.12	1.29	-0.80

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification ,LTS= Localisation of Tactile Stimuli,
MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command,
KIN= Kinaesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

***** = missing scores

4.3.2.2 Visuodyspraxia and Somatodyspraxia

Visuodyspraxia and Somatodyspraxia often occur concurrently, but not in all cases.

A child with Visuodyspraxia often has low scores on DC, accompanied by a low score on CPr, SV or MAc. FI may often score low too (Ayres, 2004, p142). **Table 4.17** highlights the scores of members of the study population which tested in the dysfunctional range in tests of visuodyspraxia. Analysis of the pattern of dysfunctional scores in visual-practic tests, indicated that a possible 22 members of the study population experienced some level of visuodyspraxia (n=22/39; 56%). Eight of these members of the study population had low scores in DC and one other visuopractic test, 5 had low scores in DC and two additional visuopractic tests and 9 had low scores in DC and all three other diagnostic visuopractic tests. Two of the members of the study population refused to participate in the MAc subtest, and one refused the FI test. These refusals were accompanied by increased levels of anxiety, withdrawal and drop in mood, possibly indicating that these members of the study population considered the task too challenging and may have performed poorly on it. Fifty six percent (56%) of the study population experienced difficulties with visuopractic tests, indicating some level of visuodyspraxia.

Somatodyspraxia is characterised by low scores on PPr, SPR or OPr and two of the remaining 4 somatosensory tests, namely FI, GRA, SWB and KIN (Ayres, 2004, p142). **Table 4.18** highlights members of the study population with low scores in this group. A total of 24 members of the study population (n=24/39; 62%) of the study population received scores indicative of a possible somatodyspraxia. Of these members of the study population, 3 had low scores in three of the somatosensory and practic tests, 6 scored low in four of these tests, 9 scored low in five tests, 5 scored low in six tests, and 1 child scored low in all seven tests of somatopractic functioning. Once again there were missing test scores due to members of the study population refusing to participate in the subtest and having and extreme negative reaction to the perceived pressure and requirements of the test. These members of the study population performed poorly in the other subtests in the section and may be considered to have a degree of somatodyspraxia. Sixty two percent (62%) of the study population appeared to have some degree of somatodyspraxia on analysis of score patterns.

If visuo- and somatodyspraxia are analysed together, it becomes evident that 15 members of the study population had scores indicating the presence of visuodyspraxia with somatodyspraxia, whilst 7 members of the study population’s score patterns indicated visuodyspraxia and 8 members of the study population’s scores could be better accounted for by the presence of somatodyspraxia.

Table 4.17 SIPT scores (SD) indicating possible Visuodyspraxia

Child	SV	FG	DC	CPr	MAc	FI	LTS	MFP	GRA	BMC	PPr	SPr	OPr	PrVC	KIN	SWB	PRN
1	-0.91	0.76	-2.56	-3.00	-0.14	1.49	-0.70	-2.47	-1.17	-1.10	0.92	-0.72	1.16	-1.11	-1.88	-0.02	-2.35
2	-0.10	-1.26	-1.17	-0.93	-0.13	1.21	-0.75	-1.76	0.19	0.66	-0.20	-1.41	1.60	-0.39	-3.00	0.32	-1.01
3	-0.78	0.24	-1.25	-0.06	-2.28	-0.01	2.14	-1.59	-2.24	0.55	0.28	-0.03	1.51	-2.98	-1.05	0.71	-1.68
4	-1.84	-2.77	-2.92	-2.73	1.35	-1.54	-0.08	-1.42	-2.12	-0.63	-1.68	-0.96	-0.75	-3.00	-3.00	-1.85	-1.09
5	-1.40	-2.12	-3.00	-1.44	-2.02	-2.70	-3.00	-3.00	-1.80	-1.77	-2.13	-0.64	-0.85	-3.00	-3.00	-2.79	-1.01
6	-1.30	-2.30	0.63	-1.69	2.75	-1.19	-1.99	-3.00	-1.90	0.13	0.06	-2.24	0.07	-2.96	-1.71	0.45	-0.76
7	0.56	-0.22	1.93	0.76	2.23	1.89	-1.26	0.54	-0.44	0.95	-0.18	0.05	-1.55	-0.84	1.20	0.60	-0.78
8	-0.56	-0.54	-0.91	-0.74	-0.41	-1.54	-0.61	-2.93	-0.72	-0.30	-1.29	-1.38	-0.68	-1.98	-1.63	-1.24	0.15
9	0.83	1.28	0.65	1.34	2.04	0.42	1.02	-0.35	-0.60	2.23	-0.70	1.50	0.64	-1.56	-0.47	-0.11	-2.01
10	-1.51	-0.81	-3.00	-1.01	-2.81	-2.20	-3.00	-2.94	-1.16	-0.86	-1.82	-2.85	-1.38	-3.00	0.10	-1.61	-1.70
11	-3.00	-2.41	-2.89	-3.00	*	*	*	-3.00	*	-0.91	-2.21	-2.64	-2.01	-3.00	*	-2.04	0.01
12	-1.62	-1.80	-3.00	-2.28	*	-3.00	-2.42	-3.00	-2.48	-1.85	-2.32	-2.88	-1.59	-1.65	-3.00	-0.71	-1.95
13	-1.78	-2.70	-3.00	-2.24	-2.46	-1.33	-2.13	-3.00	-1.54	-2.04	-3.00	-1.41	-1.55	-3.00	-1.35	-3.00	-1.01
14	-0.87	-1.02	-3.00	-0.80	-2.77	0.96	2.55	-0.12	0.33	2.37	-0.40	1.03	1.34	-1.31	0.73	2.65	-1.14
15	-2.34	-1.53	-3.00	-2.41	-1.53	-3.00	-3.00	-3.00	-2.47	-0.91	-2.85	-1.78	-0.52	-3.00	-3.00	-3.00	0.63
16	-1.02	-2.32	-2.89	-0.90	-0.42	-1.27	-1.92	-3.00	-1.40	0.35	0.03	-0.69	-0.21	-3.00	-3.00	-0.04	-1.55
17	-3.00	-1.51	-3.00	-0.89	-1.83	-1.54	-3.00	-1.80	-1.60	-0.27	-1.90	-1.15	-1.35	-2.14	-1.92	-0.35	-1.40
18	-1.80	0.27	1.19	-0.56	0.97	-0.93	1.84	-1.32	-0.44	0.35	-1.79	-1.03	-0.60	-0.84	1.32	1.01	-0.48
19	-1.16	-1.76	-2.48	-1.89	-2.74	-1.09	-1.75	-2.51	-1.91	-1.52	-1.58	-2.62	-0.07	-3.00	-3.00	-0.88	-1.82
20	-1.46	-1.16	-2.75	-1.46	-0.82	2.02	-0.07	-2.71	-0.73	-0.52	-0.03	-1.30	0.20	-3.00	-3.00	0.09	-1.51
21	-0.62	-0.49	-0.97	-0.68	1.61	-0.79	-1.97	-0.24	-2.40	1.70	-0.21	-1.22	-0.61	-3.00	-1.84	0.02	-1.16
22	-2.28	-2.39	-2.19	-1.06	-1.18	-3.00	-3.00	-1.65	-1.60	-1.42	-0.67	-1.89	-2.19	-2.35	*	-0.40	-1.04
23	-1.50	-2.31	-3.00	-1.87	0.14	-2.11	-1.12	-3.00	-0.74	-1.54	-2.21	-2.07	0.01	-2.96	-1.75	-1.93	-0.10
24	-1.60	-1.62	-2.41	-2.03	0.94	-0.39	1.61	-0.66	-2.40	-1.44	-2.91	-2.56	-0.38	-3.00	0.96	0.50	1.44

Child	SV	FG	DC	CPr	MAc	FI	LTS	MFP	GRA	BMC	PPr	SPr	OPr	PrVC	KIN	SWB	PRN
25	0.51	-0.23	0.67	-0.17	-1.32	0.45	-0.15	-3.00	-1.25	1.04	-1.68	-0.41	0.35	-3.00	-0.81	-2.77	-1.37
26	-1.39	0.80	-0.19	0.60	-2.25	0.63	0.59	-1.15	-0.09	1.91	-0.29	-0.40	-0.70	-3.00	0.53	-3.00	-1.04
27	-0.66	-1.25	-1.67	-1.36	1.02	-0.71	1.00	-2.51	-1.47	-0.22	-1.14	-0.47	0.82	-3.00	-2.68	0.72	0.77
28	-1.52	-1.53	-2.87	-2.02	-2.30	-0.94	-0.77	-2.18	-0.74	-1.70	-2.64	-1.55	-1.95	-2.96	-1.13	-1.21	-2.08
29	-0.18	-1.85	-3.00	-0.53	-2.66	-1.25	0.55	-1.53	-3.00	-1.02	-3.00	-2.79	0.11	-3.00	-2.45	-1.02	-0.17
30	-0.73	-1.58	-1.52	-0.54	-0.88	-0.35	-0.63	0.64	-0.92	-1.68	-1.08	-0.65	-0.24	0.39	-3.00	0.75	-1.08
31	-1.60	-1.40	-3.00	-2.33	-3.00	0.00	0.95	-3.00	-1.66	-1.79	-2.10	-3.00	-2.62	-3.00	-1.00	-0.42	-2.21
32	-1.62	-0.91	-0.06	0.53	0.65	-0.64	-1.35	-3.00	-2.74	-0.33	0.92	-1.00	-2.38	-3.00	0.44	-3.00	-0.37
33	-1.87	-1.63	-1.31	-0.35	2.58	-1.67	-0.03	-1.10	-0.68	0.93	-0.37	-0.23	-0.35	-3.00	-0.19	0.82	-1.49
34	-1.34	-1.85	0.95	0.16	-2.93	0.80	0.15	1.05	-2.15	0.65	-0.48	-0.34	-0.16	-3.00	0.19	-1.07	-2.07
35	-2.08	-0.77	-2.30	-1.58	-2.24	-2.57	*	-0.50	-1.37	-0.61	-1.69	-0.40	0.83	-3.00	*	-1.65	-0.91
36	-2.94	-2.30	-2.44	-1.24	-1.14	-0.83	-3.00	-2.39	-1.68	-1.18	-3.00	-2.53	-2.92	-3.00	-2.65	0.55	0.95
37	-2.58	0.53	-0.72	-1.26	-1.01	-0.74	-2.21	-3.00	-1.03	-0.48	-1.24	-0.24	-1.11	-3.00	-2.36	0.32	0.36
38	-2.58	-0.71	0.93	1.66	0.83	0.53	-3.00	0.37	0.19	1.99	0.21	-0.11	-0.36	-0.87	0.01	1.01	0.70
39	0.09	-1.33	-1.02	-0.17	-2.37	1.53	-0.90	-0.24	-1.15	0.20	-0.88	-0.21	1.26	-3.00	-1.12	1.29	-0.80

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification,LTS= Localisation of Tactile Stimuli,
MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= KInesthesia, SWB= Standing and Walking Balance, PRN= Postrotary nystagmus)

***** = missing scores

Table 4.18 SIPT scores indicating possible Somatodyspraxia

Child	SV	FG	DC	CPr	MAc	FI	LTS	MFP	GRA	BMC	PPr	SPr	OPr	PrVC	KIN	SWB	PRN
1	-0.91	0.76	-2.56	-3.00	-0.14	1.49	-0.70	-2.47	-1.17	-1.10	0.92	-0.72	1.16	-1.11	-1.88	-0.02	-2.35
2	-0.10	-1.26	-1.17	-0.93	-0.13	1.21	-0.75	-1.76	0.19	0.66	-0.20	-1.41	1.60	-0.39	-3.00	0.32	-1.01
3	-0.78	0.24	-1.25	-0.06	-2.28	-0.01	2.14	-1.59	-2.24	0.55	0.28	-0.03	1.51	-2.98	-1.05	0.71	-1.68
4	-1.84	-2.77	-2.92	-2.73	1.35	-1.54	-0.08	-1.42	-2.12	-0.63	-1.68	-0.96	-0.75	-3.00	-3.00	-1.85	-1.09
5	-1.40	-2.12	-3.00	-1.44	-2.02	-2.70	-3.00	-3.00	-1.80	-1.77	-2.13	-0.64	-0.85	-3.00	-3.00	-2.79	-1.01
6	-1.30	-2.30	0.63	-1.69	2.75	-1.19	-1.99	-3.00	-1.90	0.13	0.06	-2.24	0.07	-2.96	-1.71	0.45	-0.76
7	0.56	-0.22	1.93	0.76	2.23	1.89	-1.26	0.54	-0.44	0.95	-0.18	0.05	-1.55	-0.84	1.20	0.60	-0.78
8	-0.56	-0.54	-0.91	-0.74	-0.41	-1.54	-0.61	-2.93	-0.72	-0.30	-1.29	-1.38	-0.68	-1.98	-1.63	-1.24	0.15
9	0.83	1.28	0.65	1.34	2.04	0.42	1.02	-0.35	-0.60	2.23	-0.70	1.50	0.64	-1.56	-0.47	-0.11	-2.01
10	-1.51	-0.81	-3.00	-1.01	-2.81	-2.20	-3.00	-2.94	-1.16	-0.86	-1.82	-2.85	-1.38	-3.00	0.10	-1.61	-1.70
11	-3.00	-2.41	-2.89	-3.00	*	*	*	-3.00	*	-0.91	-2.21	-2.64	-2.01	-3.00	*	-2.04	0.01
12	-1.62	-1.80	-3.00	-2.28	*	-3.00	-2.42	-3.00	-2.48	-1.85	-2.32	-2.88	-1.59	-1.65	-3.00	-0.71	-1.95
13	-1.78	-2.70	-3.00	-2.24	-2.46	-1.33	-2.13	-3.00	-1.54	-2.04	-3.00	-1.41	-1.55	-3.00	-1.35	-3.00	-1.01
14	-0.87	-1.02	-3.00	-0.80	-2.77	0.96	2.55	-0.12	0.33	2.37	-0.40	1.03	1.34	-1.31	0.73	2.65	-1.14
15	-2.34	-1.53	-3.00	-2.41	-1.53	-3.00	-3.00	-3.00	-2.47	-0.91	-2.85	-1.78	-0.52	-3.00	-3.00	-3.00	0.63
16	-1.02	-2.32	-2.89	-0.90	-0.42	-1.27	-1.92	-3.00	-1.40	0.35	0.03	-0.69	-0.21	-3.00	-3.00	-0.04	-1.55
17	-3.00	-1.51	-3.00	-0.89	-1.83	-1.54	-3.00	-1.80	-1.60	-0.27	-1.90	-1.15	-1.35	-2.14	-1.92	-0.35	-1.40
18	-1.80	0.27	1.19	-0.56	0.97	-0.93	1.84	-1.32	-0.44	0.35	-1.79	-1.03	-0.60	-0.84	1.32	1.01	-0.48
19	-1.16	-1.76	-2.48	-1.89	-2.74	-1.09	-1.75	-2.51	-1.91	-1.52	-1.58	-2.62	-0.07	-3.00	-3.00	-0.88	-1.82
20	-1.46	-1.16	-2.75	-1.46	-0.82	2.02	-0.07	-2.71	-0.73	-0.52	-0.03	-1.30	0.20	-3.00	-3.00	0.09	-1.51
21	-0.62	-0.49	-0.97	-0.68	1.61	-0.79	-1.97	-0.24	-2.40	1.70	-0.21	-1.22	-0.61	-3.00	-1.84	0.02	-1.16
22	-2.28	-2.39	-2.19	-1.06	-1.18	-3.00	-3.00	-1.65	-1.60	-1.42	-0.67	-1.89	-2.19	-2.35	*	-0.40	-1.04
23	-1.50	-2.31	-3.00	-1.87	0.14	-2.11	-1.12	-3.00	-0.74	-1.54	-2.21	-2.07	0.01	-2.96	-1.75	-1.93	-0.10
24	-1.60	-1.62	-2.41	-2.03	0.94	-0.39	1.61	-0.66	-2.40	-1.44	-2.91	-2.56	-0.38	-3.00	0.96	0.50	1.44
25	0.51	-0.23	0.67	-0.17	-1.32	0.45	-0.15	-3.00	-1.25	1.04	-1.68	-0.41	0.35	-3.00	-0.81	-2.77	-1.37

Child	SV	FG	DC	CPr	MAc	FI	LTS	MFP	GRA	BMC	PPr	SPr	OPr	PrVC	KIN	SWB	PRN
26	-1.39	0.80	-0.19	0.60	-2.25	0.63	0.59	-1.15	-0.09	1.91	-0.29	-0.40	-0.70	-3.00	0.53	-3.00	-1.04
27	-0.66	-1.25	-1.67	-1.36	1.02	-0.71	1.00	-2.51	-1.47	-0.22	-1.14	-0.47	0.82	-3.00	-2.68	0.72	0.77
28	-1.52	-1.53	-2.87	-2.02	-2.30	-0.94	-0.77	-2.18	-0.74	-1.70	-2.64	-1.55	-1.95	-2.96	-1.13	-1.21	-2.08
29	-0.18	-1.85	-3.00	-0.53	-2.66	-1.25	0.55	-1.53	-3.00	-1.02	-3.00	-2.79	0.11	-3.00	-2.45	-1.02	-0.17
30	-0.73	-1.58	-1.52	-0.54	-0.88	-0.35	-0.63	0.64	-0.92	-1.68	-1.08	-0.65	-0.24	0.39	-3.00	0.75	-1.08
31	-1.60	-1.40	-3.00	-2.33	-3.00	0.00	0.95	-3.00	-1.66	-1.79	-2.10	-3.00	-2.62	-3.00	-1.00	-0.42	-2.21
32	-1.62	-0.91	-0.06	0.53	0.65	-0.64	-1.35	-3.00	-2.74	-0.33	0.92	-1.00	-2.38	-3.00	0.44	-3.00	-0.37
33	-1.87	-1.63	-1.31	-0.35	2.58	-1.67	-0.03	-1.10	-0.68	0.93	-0.37	-0.23	-0.35	-3.00	-0.19	0.82	-1.49
34	-1.34	-1.85	0.95	0.16	-2.93	0.80	0.15	1.05	-2.15	0.65	-0.48	-0.34	-0.16	-3.00	0.19	-1.07	-2.07
35	-2.08	-0.77	-2.30	-1.58	-2.24	-2.57	*	-0.50	-1.37	-0.61	-1.69	-0.40	0.83	-3.00	*	-1.65	-0.91
36	-2.94	-2.30	-2.44	-1.24	-1.14	-0.83	-3.00	-2.39	-1.68	-1.18	-3.00	-2.53	-2.92	-3.00	-2.65	0.55	0.95
37	-2.58	0.53	-0.72	-1.26	-1.01	-0.74	-2.21	-3.00	-1.03	-0.48	-1.24	-0.24	-1.11	-3.00	-2.36	0.32	0.36
38	-2.58	-0.71	0.93	1.66	0.83	0.53	-3.00	0.37	0.19	1.99	0.21	-0.11	-0.36	-0.87	0.01	1.01	0.70
39	0.09	-1.33	-1.02	-0.17	-2.37	1.53	-0.90	-0.24	-1.15	0.20	-0.88	-0.21	1.26	-3.00	-1.12	1.29	-0.80

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli,
MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= KInesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

***** = missing scores

4.3.2.3 Generalised Sensory Integrative Disorder

A generalised sensory integrative disorder is characterised by below average or dysfunctional scores in all major areas tested. There may be no obviously identifiable pattern. High scores may be present in BMC, SWB and LTS, but these are considered unimportant in the interpretation of score patterns for a generalised dysfunction (Ayres, 2004, p141). A high score on MAc is however considered to be significant. In **Table 4.19**, dysfunctional scores indicative of a possible generalised dysfunction have been highlighted. Fourteen members of the study population (n=14/39; 36%) in the study population had scores indicating a possible generalised dysfunction. Thirteen of these members of the study population were also determined to have a visuo and somatodyspraxia (discussed in **Section 4.3.2.2**, **table 4.17** and **table 4.18**), in addition to difficulties in other major areas including form and space perception and vestibular and proprioceptive processing. Their performance across the major areas of functioning determined by the SIPT was poor.

Table 4.19 SIPT scores (SD) indicating possible Generalised Sensory Integrative Disorder

Child	***SV***	***FG***	**DC**	**CPr**	**MAc**	**FI**	**LTS**	**MFP**	**GRA**	**BMC**	**PPr**	**SPr**	**OPr**	**PrVC**	**KIN**	**SWB**	**PRN**
1	*-0.91*	*0.76*	-2.56	-3.00	-0.14	1.49	-0.70	-2.47	-1.17	-1.10	0.92	-0.72	1.16	-1.11	-1.88	-0.02	-2.35
2	*-0.10*	*-1.26*	-1.17	-0.93	-0.13	1.21	-0.75	-1.76	0.19	0.66	-0.20	-1.41	1.60	-0.39	-3.00	0.32	-1.01
3	*-0.78*	*0.24*	-1.25	-0.06	-2.28	-0.01	2.14	-1.59	-2.24	0.55	0.28	-0.03	1.51	-2.98	-1.05	0.71	-1.68
4	*-1.84*	*-2.77*	-2.92	-2.73	1.35	-1.54	-0.08	-1.42	-2.12	-0.63	-1.68	-0.96	-0.75	-3.00	-3.00	-1.85	-1.09
5	*-1.40*	*-2.12*	-3.00	-1.44	-2.02	-2.70	-3.00	-3.00	-1.80	-1.77	-2.13	-0.64	-0.85	-3.00	-3.00	-2.79	-1.01
6	*-1.30*	*-2.30*	0.63	-1.69	2.75	-1.19	-1.99	-3.00	-1.90	0.13	0.06	-2.24	0.07	-2.96	-1.71	0.45	-0.76
7	*0.56*	*-0.22*	1.93	0.76	2.23	1.89	-1.26	0.54	-0.44	0.95	-0.18	0.05	-1.55	-0.84	1.20	0.60	-0.78
8	*-0.56*	*-0.54*	-0.91	-0.74	-0.41	-1.54	-0.61	-2.93	-0.72	-0.30	-1.29	-1.38	-0.68	-1.98	-1.63	-1.24	0.15
9	*0.83*	*1.28*	0.65	1.34	2.04	0.42	1.02	-0.35	-0.60	2.23	-0.70	1.50	0.64	-1.56	-0.47	-0.11	-2.01
10	*-1.51*	*-0.81*	-3.00	-1.01	-2.81	-2.20	-3.00	-2.94	-1.16	-0.86	-1.82	-2.85	-1.38	-3.00	0.10	-1.61	-1.70
11	*-3.00*	*-2.41*	-2.89	-3.00	*	*	*	-3.00	*	-0.91	-2.21	-2.64	-2.01	-3.00	*	-2.04	0.01
12	*-1.62*	*-1.80*	-3.00	-2.28	*	-3.00	-2.42	-3.00	-2.48	-1.85	-2.32	-2.88	-1.59	-1.65	-3.00	-0.71	-1.95
13	*-1.78*	*-2.70*	-3.00	-2.24	-2.46	-1.33	-2.13	-3.00	-1.54	-2.04	-3.00	-1.41	-1.55	-3.00	-1.35	-3.00	-1.01
14	*-0.87*	*-1.02*	-3.00	-0.80	-2.77	0.96	2.55	-0.12	0.33	2.37	-0.40	1.03	1.34	-1.31	0.73	2.65	-1.14
15	*-2.34*	*-1.53*	-3.00	-2.41	-1.53	-3.00	-3.00	-3.00	-2.47	-0.91	-2.85	-1.78	-0.52	-3.00	-3.00	-3.00	0.63
16	*-1.02*	*-2.32*	-2.89	-0.90	-0.42	-1.27	-1.92	-3.00	-1.40	0.35	0.03	-0.69	-0.21	-3.00	-3.00	-0.04	-1.55
17	*-3.00*	*-1.51*	-3.00	-0.89	-1.83	-1.54	-3.00	-1.80	-1.60	-0.27	-1.90	-1.15	-1.35	-2.14	-1.92	-0.35	-1.40
18	*-1.80*	*0.27*	1.19	-0.56	0.97	-0.93	1.84	-1.32	-0.44	0.35	-1.79	-1.03	-0.60	-0.84	1.32	1.01	-0.48
19	*-1.16*	*-1.76*	-2.48	-1.89	-2.74	-1.09	-1.75	-2.51	-1.91	-1.52	-1.58	-2.62	-0.07	-3.00	-3.00	-0.88	-1.82
20	*-1.46*	*-1.16*	-2.75	-1.46	-0.82	2.02	-0.07	-2.71	-0.73	-0.52	-0.03	-1.30	0.20	-3.00	-3.00	0.09	-1.51
21	*-0.62*	*-0.49*	-0.97	-0.68	1.61	-0.79	-1.97	-0.24	-2.40	1.70	-0.21	-1.22	-0.61	-3.00	-1.84	0.02	-1.16
22	*-2.28*	*-2.39*	-2.19	-1.06	-1.18	-3.00	-3.00	-1.65	-1.60	-1.42	-0.67	-1.89	-2.19	-2.35	*	-0.40	-1.04
23	*-1.50*	*-2.31*	-3.00	-1.87	0.14	-2.11	-1.12	-3.00	-0.74	-1.54	-2.21	-2.07	0.01	-2.96	-1.75	-1.93	-0.10
24	*-1.60*	*-1.62*	-2.41	-2.03	0.94	-0.39	1.61	-0.66	-2.40	-1.44	-2.91	-2.56	-0.38	-3.00	0.96	0.50	1.44

Child	***SV***	***FG***	**DC**	**CPr**	**MAc**	**FI**	**LTS**	**MFP**	**GRA**	**BMC**	**PPr**	**SPr**	**OPr**	**PrVC**	**KIN**	**SWB**	**PRN**
25	*0.51*	*-0.23*	0.67	-0.17	-1.32	0.45	-0.15	-3.00	-1.25	1.04	-1.68	-0.41	0.35	-3.00	-0.81	-2.77	-1.37
26	*-1.39*	*0.80*	-0.19	0.60	-2.25	0.63	0.59	-1.15	-0.09	1.91	-0.29	-0.40	-0.70	-3.00	0.53	-3.00	-1.04
27	*-0.66*	*-1.25*	-1.67	-1.36	1.02	-0.71	1.00	-2.51	-1.47	-0.22	-1.14	-0.47	0.82	-3.00	-2.68	0.72	0.77
28	*-1.52*	*-1.53*	-2.87	-2.02	-2.30	-0.94	-0.77	-2.18	-0.74	-1.70	-2.64	-1.55	-1.95	-2.96	-1.13	-1.21	-2.08
29	*-0.18*	*-1.85*	-3.00	-0.53	-2.66	-1.25	0.55	-1.53	-3.00	-1.02	-3.00	-2.79	0.11	-3.00	-2.45	-1.02	-0.17
30	*-0.73*	*-1.58*	-1.52	-0.54	-0.88	-0.35	-0.63	0.64	-0.92	-1.68	-1.08	-0.65	-0.24	0.39	-3.00	0.75	-1.08
31	*-1.60*	*-1.40*	-3.00	-2.33	-3.00	0.00	0.95	-3.00	-1.66	-1.79	-2.10	-3.00	-2.62	-3.00	-1.00	-0.42	-2.21
32	-1.62	*-0.91*	-0.06	0.53	0.65	-0.64	-1.35	-3.00	-2.74	-0.33	0.92	-1.00	-2.38	-3.00	0.44	-3.00	-0.37
33	-1.87	*-1.63*	-1.31	-0.35	2.58	-1.67	-0.03	-1.10	-0.68	0.93	-0.37	-0.23	-0.35	-3.00	-0.19	0.82	-1.49
34	-1.34	*-1.85*	0.95	0.16	-2.93	0.80	0.15	1.05	-2.15	0.65	-0.48	-0.34	-0.16	-3.00	0.19	-1.07	-2.07
35	-2.08	*-0.77*	-2.30	-1.58	-2.24	-2.57	*	-0.50	-1.37	-0.61	-1.69	-0.40	0.83	-3.00	*	-1.65	-0.91
36	-2.94	*-2.30*	-2.44	-1.24	-1.14	-0.83	-3.00	-2.39	-1.68	-1.18	-3.00	-2.53	-2.92	-3.00	-2.65	0.55	0.95
37	-2.58	*0.53*	-0.72	-1.26	-1.01	-0.74	-2.21	-3.00	-1.03	-0.48	-1.24	-0.24	-1.11	-3.00	-2.36	0.32	0.36
38	-2.58	*-0.71*	0.93	1.66	0.83	0.53	-3.00	0.37	0.19	1.99	0.21	-0.11	-0.36	-0.87	0.01	1.01	0.70
39	0.09	*-1.33*	-1.02	-0.17	-2.37	1.53	-0.90	-0.24	-1.15	0.20	-0.88	-0.21	1.26	-3.00	-1.12	1.29	-0.80

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= Kinaesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

***** = missing scores

4.3.2.4 Dyspraxia on Verbal Command

Dyspraxia on verbal command is characterised by a low score in PrVC coupled with an average to high score in PRN. In addition to this, scores in the low average range and higher are seen in tests of visuopraxis, somatosensory processing and PPr with a relatively high score in CPr. This disorder if further characterised by low scores in 4 of the 5 remaining praxis tests, namely OPr, SPr, BMC, SWB and GRA. These low scores are considered to be as a result of cerebral inefficiency. Dyspraxia on verbal command has a postural and linguistic component to it. The disorder can be considered to have more of a postural base if PPr scores within the dysfunctional range. Very low PrVC scores indicate a possible deficit in the linguistic component of functioning (Ayres, 2004, p145).

Table 4.20 highlights members of the study population who could be considered to have this type of disorder. Only 1 child (n=1/39; 2.6%) could be considered to possibly fall into this diagnostic group after analysis of the score pattern. This same child was also considered to possibly have a degree of somatodyspraxia **(cf Table 4.18),** and appeared thus to have somatodyspraxia with an added linguistic component.

Table 4.20 SIPT scores (SD) possibly indicating Dyspraxia on verbal command

Child	SV	FG	DC	CPr	MAc	FI	LTS	MFP	GRA	BMC	PPr	SPr	OPr	PrVC	KIN	SWB	PRN
1	-0.91	0.76	-2.56	-3.00	-0.14	1.49	-0.70	-2.47	-1.17	-1.10	0.92	-0.72	1.16	-1.11	-1.88	-0.02	-2.35
2	-0.10	-1.26	-1.17	-0.93	-0.13	1.21	-0.75	-1.76	0.19	0.66	-0.20	-1.41	1.60	-0.39	-3.00	0.32	-1.01
3	-0.78	0.24	-1.25	-0.06	-2.28	-0.01	2.14	-1.59	-2.24	0.55	0.28	-0.03	1.51	-2.98	-1.05	0.71	-1.68
4	-1.84	-2.77	-2.92	-2.73	1.35	-1.54	-0.08	-1.42	-2.12	-0.63	-1.68	-0.96	-0.75	-3.00	-3.00	-1.85	-1.09
5	-1.40	-2.12	-3.00	-1.44	-2.02	-2.70	-3.00	-3.00	-1.80	-1.77	-2.13	-0.64	-0.85	-3.00	-3.00	-2.79	-1.01
6	-1.30	-2.30	0.63	-1.69	2.75	-1.19	-1.99	-3.00	-1.90	0.13	0.06	-2.24	0.07	-2.96	-1.71	0.45	-0.76
7	0.56	-0.22	1.93	0.76	2.23	1.89	-1.26	0.54	-0.44	0.95	-0.18	0.05	-1.55	-0.84	1.20	0.60	-0.78
8	-0.56	-0.54	-0.91	-0.74	-0.41	-1.54	-0.61	-2.93	-0.72	-0.30	-1.29	-1.38	-0.68	-1.98	-1.63	-1.24	0.15
9	0.83	1.28	0.65	1.34	2.04	0.42	1.02	-0.35	-0.60	2.23	-0.70	1.50	0.64	-1.56	-0.47	-0.11	-2.01
10	-1.51	-0.81	-3.00	-1.01	-2.81	-2.20	-3.00	-2.94	-1.16	-0.86	-1.82	-2.85	-1.38	-3.00	0.10	-1.61	-1.70
11	-3.00	-2.41	-2.89	-3.00	*	*	*		*	-0.91	-2.21	-2.64	-2.01	-3.00	*	-2.04	0.01
12	-1.62	-1.80	-3.00	-2.28	*	-3.00	-2.42	-3.00	-2.48	-1.85	-2.32	-2.88	-1.59	-1.65	-3.00	-0.71	-1.95
13	-1.78	-2.70	-3.00	-2.24	-2.46	-1.33	-2.13	-3.00	-1.54	-2.04	-3.00	-1.41	-1.55	-3.00	-1.35	-3.00	-1.01
14	-0.87	-1.02	-3.00	-0.80	-2.77	0.96	2.55	-0.12	0.33	2.37	-0.40	1.03	1.34	-1.31	0.73	2.65	-1.14
15	-2.34	-1.53	-3.00	-2.41	-1.53	-3.00	-3.00	-3.00	-2.47	-0.91	-2.85	-1.78	-0.52	-3.00	-3.00	-3.00	0.63
16	-1.02	-2.32	-2.89	-0.90	-0.42	-1.27	-1.92	-3.00	-1.40	0.35	0.03	-0.69	-0.21	-3.00	-3.00	-0.04	-1.55
17	-3.00	-1.51	-3.00	-0.89	-1.83	-1.54	-3.00	-1.80	-1.60	-0.27	-1.90	-1.15	-1.35	-2.14	-1.92	-0.35	-1.40
18	-1.80	0.27	1.19	-0.56	0.97	-0.93	1.84	-1.32	-0.44	0.35	-1.79	-1.03	-0.60	-0.84	1.32	1.01	-0.48
19	-1.16	-1.76	-2.48	-1.89	-2.74	-1.09	-1.75	-2.51	-1.91	-1.52	-1.58	-2.62	-0.07	-3.00	-3.00	-0.88	-1.82
20	-1.46	-1.16	-2.75	-1.46	-0.82	2.02	-0.07	-2.71	-0.73	-0.52	-0.03	-1.30	0.20	-3.00	-3.00	0.09	-1.51
21	-0.62	-0.49	-0.97	-0.68	1.61	-0.79	-1.97	-0.24	-2.40	1.70	-0.21	-1.22	-0.61	-3.00	-1.84	0.02	-1.16
22	-2.28	-2.39	-2.19	-1.06	-1.18	-3.00	-3.00	-1.65	-1.60	-1.42	-0.67	-1.89	-2.19	-2.35	*	-0.40	-1.04
23	-1.50	-2.31	-3.00	-1.87	0.14	-2.11	-1.12	-3.00	-0.74	-1.54	-2.21	-2.07	0.01	-2.96	-1.75	-1.93	-0.10
24	-1.60	-1.62	-2.41	-2.03	0.94	-0.39	1.61	-0.66	-2.40	-1.44	-2.91	-2.56	-0.38	-3.00	0.96	0.50	1.44

Child	SV	FG	DC	CPr	MAc	FI	LTS	MFP	GRA	BMC	PPr	SPr	OPr	PrVC	KIN	SWB	PRN
25	0.51	-0.23	0.67	-0.17	-1.32	0.45	-0.15	-3.00	-1.25	1.04	-1.68	-0.41	0.35	-3.00	-0.81	-2.77	-1.37
26	-1.39	0.80	-0.19	0.60	-2.25	0.63	0.59	-1.15	-0.09	1.91	-0.29	-0.40	-0.70	-3.00	0.53	-3.00	-1.04
27	-0.66	-1.25	-1.67	-1.36	1.02	-0.71	1.00	-2.51	-1.47	-0.22	-1.14	-0.47	0.82	-3.00	-2.68	0.72	0.77
28	-1.52	-1.53	-2.87	-2.02	-2.30	-0.94	-0.77	-2.18	-0.74	-1.70	-2.64	-1.55	-1.95	-2.96	-1.13	-1.21	-2.08
29	-0.18	-1.85	-3.00	-0.53	-2.66	-1.25	0.55	-1.53	-3.00	-1.02	-3.00	-2.79	0.11	-3.00	-2.45	-1.02	-0.17
30	-0.73	-1.58	-1.52	-0.54	-0.88	-0.35	-0.63	0.64	-0.92	-1.68	-1.08	-0.65	-0.24	0.39	-3.00	0.75	-1.08
31	-1.60	-1.40	-3.00	-2.33	-3.00	0.00	0.95	-3.00	-1.66	-1.79	-2.10	-3.00	-2.62	-3.00	-1.00	-0.42	-2.21
32	-1.62	-0.91	-0.06	0.53	0.65	-0.64	-1.35	-3.00	-2.74	-0.33	0.92	-1.00	-2.38	-3.00	0.44	-3.00	-0.37
33	-1.87	-1.63	-1.31	-0.35	2.58	-1.67	-0.03	-1.10	-0.68	0.93	-0.37	-0.23	-0.35	-3.00	-0.19	0.82	-1.49
34	-1.34	-1.85	0.95	0.16	-2.93	0.80	0.15	1.05	-2.15	0.65	-0.48	-0.34	-0.16	-3.00	0.19	-1.07	-2.07
35	-2.08	-0.77	-2.30	-1.58	-2.24	-2.57	*	-0.50	-1.37	-0.61	-1.69	-0.40	0.83	-3.00	*	-1.65	-0.91
36	-2.94	-2.30	-2.44	-1.24	-1.14	-0.83	-3.00	-2.39	-1.68	-1.18	-3.00	-2.53	-2.92	-3.00	-2.65	0.55	0.95
37	-2.58	0.53	-0.72	-1.26	-1.01	-0.74	-2.21	-3.00	-1.03	-0.48	-1.24	-0.24	-1.11	-3.00	-2.36	0.32	0.36
38	-2.58	-0.71	0.93	1.66	0.83	0.53	-3.00	0.37	0.19	1.99	0.21	-0.11	-0.36	-0.87	0.01	1.01	0.70
39	0.09	-1.33	-1.02	-0.17	-2.37	1.53	-0.90	-0.24	-1.15	0.20	-0.88	-0.21	1.26	-3.00	-1.12	1.29	-0.80

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= Kinaesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

***** = missing score

4.3.3 Analysis of SIPT scores in Partial Patterns

Partial pattern analysis may be used in interpretation of SIPT scores when only part of the score pattern seems to fit a profile. There are natural linkages among subtests in the SIPT, determined by large scale factor analysis (Ayres, 2004, 134). The partial patterns are identified and analysed in the following sections.

4.3.3.1 Partial pattern 1: Inefficient Vestibular Processing associated with poor Visual Processing

This pattern is characterised by scores in the dysfunctional range in PRN, DC, CPr, SV, FI, MAc, MFP and FG. Low scores in PRN indicate a low responsivity of the CNS to vestibular input, and thus inefficient processing of vestibular information. This inefficient processing has been shown to be related to visuopractic abilities and somatosensory processing, with poor scores achieved here if vestibular processing is inefficient (Ayres, 2004, p134, 136). **Table 4.21** highlights scores in the dysfunctional range in PRN, DC, CPr, SV, FI, MAc, MFP and FG. Three members of the study population met these criteria (n=3/39; 8%). These members of the study population also received scores in a pattern indicating a possible visuo dyspraxia with a somatodyspraxia and a generalised sensory integrative disorder. This partial pattern of scores emphasise that these specific members of the study population had inefficient vestibular processing and inefficient visual processing as part of a greater sensory integrative disorder.

Table 4.21 Partial pattern 1: Inefficient Vestibular Processing associated with poor Visual Processing

Child	SV	FG	DC	CPr	MAc	FI	LTS	MFP	GRA	BMC	PPr	SPr	OPr	PrVC	KIN	SWB	PRN
1	-0.91	0.76	-2.56	-3.00	-0.14	1.49	-0.70	-2.47	-1.17	-1.10	0.92	-0.72	1.16	-1.11	-1.88	-0.02	-2.35
2	-0.10	-1.26	-1.17	-0.93	-0.13	1.21	-0.75	-1.76	0.19	0.66	-0.20	-1.41	1.60	-0.39	-3.00	0.32	-1.01
3	-0.78	0.24	-1.25	-0.06	-2.28	-0.01	2.14	-1.59	-2.24	0.55	0.28	-0.03	1.51	-2.98	-1.05	0.71	-1.68
4	-1.84	-2.77	-2.92	-2.73	1.35	-1.54	-0.08	-1.42	-2.12	-0.63	-1.68	-0.96	-0.75	-3.00	-3.00	-1.85	-1.09
5	-1.40	-2.12	-3.00	-1.44	-2.02	-2.70	-3.00	-3.00	-1.80	-1.77	-2.13	-0.64	-0.85	-3.00	-3.00	-2.79	-1.01
6	-1.30	-2.30	0.63	-1.69	2.75	-1.19	-1.99	-3.00	-1.90	0.13	0.06	-2.24	0.07	-2.96	-1.71	0.45	-0.76
7	0.56	-0.22	1.93	0.76	2.23	1.89	-1.26	0.54	-0.44	0.95	-0.18	0.05	-1.55	-0.84	1.20	0.60	-0.78
8	-0.56	-0.54	-0.91	-0.74	-0.41	-1.54	-0.61	-2.93	-0.72	-0.30	-1.29	-1.38	-0.68	-1.98	-1.63	-1.24	0.15
9	0.83	1.28	0.65	1.34	2.04	0.42	1.02	-0.35	-0.60	2.23	-0.70	1.50	0.64	-1.56	-0.47	-0.11	-2.01
10	-1.51	-0.81	-3.00	-1.01	-2.81	-2.20	-3.00	-2.94	-1.16	-0.86	-1.82	-2.85	-1.38	-3.00	0.10	-1.61	-1.70
11	-3.00	-2.41	-2.89	-3.00	*	*	*		*	-0.91	-2.21	-2.64	-2.01	-3.00	*	-2.04	0.01
12	-1.62	-1.80	-3.00	-2.28	*	-3.00	-2.42	-3.00	-2.48	-1.85	-2.32	-2.88	-1.59	-1.65	-3.00	-0.71	-1.95
13	-1.78	-2.70	-3.00	-2.24	-2.46	-1.33	-2.13	-3.00	-1.54	-2.04	-3.00	-1.41	-1.55	-3.00	-1.35	-3.00	-1.01
14	-0.87	-1.02	-3.00	-0.80	-2.77	0.96	2.55	-0.12	0.33	2.37	-0.40	1.03	1.34	-1.31	0.73	2.65	-1.14
15	-2.34	-1.53	-3.00	-2.41	-1.53	-3.00	-3.00	-3.00	-2.47	-0.91	-2.85	-1.78	-0.52	-3.00	-3.00	-3.00	0.63
16	-1.02	-2.32	-2.89	-0.90	-0.42	-1.27	-1.92	-3.00	-1.40	0.35	0.03	-0.69	-0.21	-3.00	-3.00	-0.04	-1.55
17	-3.00	-1.51	-3.00	-0.89	-1.83	-1.54	-3.00	-1.80	-1.60	-0.27	-1.90	-1.15	-1.35	-2.14	-1.92	-0.35	-1.40
18	-1.80	0.27	1.19	-0.56	0.97	-0.93	1.84	-1.32	-0.44	0.35	-1.79	-1.03	-0.60	-0.84	1.32	1.01	-0.48
19	-1.16	-1.76	-2.48	-1.89	-2.74	-1.09	-1.75	-2.51	-1.91	-1.52	-1.58	-2.62	-0.07	-3.00	-3.00	-0.88	-1.82
20	-1.46	-1.16	-2.75	-1.46	-0.82	2.02	-0.07	-2.71	-0.73	-0.52	-0.03	-1.30	0.20	-3.00	-3.00	0.09	-1.51
21	-0.62	-0.49	-0.97	-0.68	1.61	-0.79	-1.97	-0.24	-2.40	1.70	-0.21	-1.22	-0.61	-3.00	-1.84	0.02	-1.16
22	-2.28	-2.39	-2.19	-1.06	-1.18	-3.00	-3.00	-1.65	-1.60	-1.42	-0.67	-1.89	-2.19	-2.35	*	-0.40	-1.04
23	-1.50	-2.31	-3.00	-1.87	0.14	-2.11	-1.12	-3.00	-0.74	-1.54	-2.21	-2.07	0.01	-2.96	-1.75	-1.93	-0.10
24	-1.60	-1.62	-2.41	-2.03	0.94	-0.39	1.61	-0.66	-2.40	-1.44	-2.91	-2.56	-0.38	-3.00	0.96	0.50	1.44

Child	SV	FG	DC	CPr	MAc	FI	LTS	MFP	GRA	BMC	PPr	SPr	OPr	PrVC	KIN	SWB	PRN
25	0.51	-0.23	0.67	-0.17	-1.32	0.45	-0.15	-3.00	-1.25	1.04	-1.68	-0.41	0.35	-3.00	-0.81	-2.77	-1.37
26	-1.39	0.80	-0.19	0.60	-2.25	0.63	0.59	-1.15	-0.09	1.91	-0.29	-0.40	-0.70	-3.00	0.53	-3.00	-1.04
27	-0.66	-1.25	-1.67	-1.36	1.02	-0.71	1.00	-2.51	-1.47	-0.22	-1.14	-0.47	0.82	-3.00	-2.68	0.72	0.77
28	-1.52	-1.53	-2.87	-2.02	-2.30	-0.94	-0.77	-2.18	-0.74	-1.70	-2.64	-1.55	-1.95	-2.96	-1.13	-1.21	-2.08
29	-0.18	-1.85	-3.00	-0.53	-2.66	-1.25	0.55	-1.53	-3.00	-1.02	-3.00	-2.79	0.11	-3.00	-2.45	-1.02	-0.17
30	-0.73	-1.58	-1.52	-0.54	-0.88	-0.35	-0.63	0.64	-0.92	-1.68	-1.08	-0.65	-0.24	0.39	-3.00	0.75	-1.08
31	-1.60	-1.40	-3.00	-2.33	-3.00	0.00	0.95	-3.00	-1.66	-1.79	-2.10	-3.00	-2.62	-3.00	-1.00	-0.42	-2.21
32	-1.62	-0.91	-0.06	0.53	0.65	-0.64	-1.35	-3.00	-2.74	-0.33	0.92	-1.00	-2.38	-3.00	0.44	-3.00	-0.37
33	-1.87	-1.63	-1.31	-0.35	2.58	-1.67	-0.03	-1.10	-0.68	0.93	-0.37	-0.23	-0.35	-3.00	-0.19	0.82	-1.49
34	-1.34	-1.85	0.95	0.16	-2.93	0.80	0.15	1.05	-2.15	0.65	-0.48	-0.34	-0.16	-3.00	0.19	-1.07	-2.07
35	-2.08	-0.77	-2.30	-1.58	-2.24	-2.57	*	-0.50	-1.37	-0.61	-1.69	-0.40	0.83	-3.00	*	-1.65	-0.91
36	-2.94	-2.30	-2.44	-1.24	-1.14	-0.83	-3.00	-2.39	-1.68	-1.18	-3.00	-2.53	-2.92	-3.00	-2.65	0.55	0.95
37	-2.58	0.53	-0.72	-1.26	-1.01	-0.74	-2.21	-3.00	-1.03	-0.48	-1.24	-0.24	-1.11	-3.00	-2.36	0.32	0.36
38	-2.58	-0.71	0.93	1.66	0.83	0.53	-3.00	0.37	0.19	1.99	0.21	-0.11	-0.36	-0.87	0.01	1.01	0.70
39	0.09	-1.33	-1.02	-0.17	-2.37	1.53	-0.90	-0.24	-1.15	0.20	-0.88	-0.21	1.26	-3.00	-1.12	1.29	-0.80

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= KInesthesia, SWB= Standing and Walking Balance, PRN= Postrotary nystagmus)

* = missing scores

4.3.3.2 Partial pattern 2: Visuoconstruction deficit

A visuoconstruction deficit, can be considered when a partial pattern of scores clusters in low scores in 2 or more tests of visual construction on a two or three dimensional level, namely SV, FG, DC, MAc and CPr (Ayres, 2004, p134). **Table 4.22** highlights the scores consistent with this pattern, indicating that 30 of the members of the study population have a visuoconstructive deficit (n=30/39; 77%). Of these 30 members of the study population, many incidences of visuoconstruction deficit could be accounted for by the presence of a diagnosed sensory integrative disorder, or SIPT group. Thirteen of the members of the study population possibly had a generalised sensory integrative disorder, 7 members of the study population possibly had visuodyspraxia, 3 members of the study population possibly had a visuodyspraxia with a somatodyspraxia, 2 members of the study population seemed to have somatodyspraxia, and 1 child a dyspraxia on verbal command with a somatic component. In 4 of the members of the study population (n=4/30; 13% of the dysfunctional population in this pattern), the constellation of scores could not be accounted for by another SIPT group or disorder, and these members of the study population seemed to have a visuoconstruction deficit.

Table 4.22 Partial pattern 2: Visuoconstruction deficit

Child	SV	FG	DC	CPr	MAc	FI	LTS	MFP	GRA	BMC	PPr	SPr	OPr	PrVC	KIN	SWB	PRN
1	-0.91	0.76	-2.56	-3.00	-0.14	1.49	-0.70	-2.47	-1.17	-1.10	0.92	-0.72	1.16	-1.11	-1.88	-0.02	-2.35
2	-0.10	-1.26	-1.17	-0.93	-0.13	1.21	-0.75	-1.76	0.19	0.66	-0.20	-1.41	1.60	-0.39	-3.00	0.32	-1.01
3	-0.78	0.24	-1.25	-0.06	-2.28	-0.01	2.14	-1.59	-2.24	0.55	0.28	-0.03	1.51	-2.98	-1.05	0.71	-1.68
4	-1.84	-2.77	-2.92	-2.73	1.35	-1.54	-0.08	-1.42	-2.12	-0.63	-1.68	-0.96	-0.75	-3.00	-3.00	-1.85	-1.09
5	-1.40	-2.12	-3.00	-1.44	-2.02	-2.70	-3.00	-3.00	-1.80	-1.77	-2.13	-0.64	-0.85	-3.00	-3.00	-2.79	-1.01
6	-1.30	-2.30	0.63	-1.69	2.75	-1.19	-1.99	-3.00	-1.90	0.13	0.06	-2.24	0.07	-2.96	-1.71	0.45	-0.76
7	0.56	-0.22	1.93	0.76	2.23	1.89	-1.26	0.54	-0.44	0.95	-0.18	0.05	-1.55	-0.84	1.20	0.60	-0.78
8	-0.56	-0.54	-0.91	-0.74	-0.41	-1.54	-0.61	-2.93	-0.72	-0.30	-1.29	-1.38	-0.68	-1.98	-1.63	-1.24	0.15
9	0.83	1.28	0.65	1.34	2.04	0.42	1.02	-0.35	-0.60	2.23	-0.70	1.50	0.64	-1.56	-0.47	-0.11	-2.01
10	-1.51	-0.81	-3.00	-1.01	-2.81	-2.20	-3.00	-2.94	-1.16	-0.86	-1.82	-2.85	-1.38	-3.00	0.10	-1.61	-1.70
11	-3.00	-2.41	-2.89	-3.00	*	*	*		*	-0.91	-2.21	-2.64	-2.01	-3.00	*	-2.04	0.01
12	-1.62	-1.80	-3.00	-2.28	*	-3.00	-2.42	-3.00	-2.48	-1.85	-2.32	-2.88	-1.59	-1.65	-3.00	-0.71	-1.95
13	-1.78	-2.70	-3.00	-2.24	-2.46	-1.33	-2.13	-3.00	-1.54	-2.04	-3.00	-1.41	-1.55	-3.00	-1.35	-3.00	-1.01
14	-0.87	-1.02	-3.00	-0.80	-2.77	0.96	2.55	-0.12	0.33	2.37	-0.40	1.03	1.34	-1.31	0.73	2.65	-1.14
15	-2.34	-1.53	-3.00	-2.41	-1.53	-3.00	-3.00	-3.00	-2.47	-0.91	-2.85	-1.78	-0.52	-3.00	-3.00	-3.00	0.63
16	-1.02	-2.32	-2.89	-0.90	-0.42	-1.27	-1.92	-3.00	-1.40	0.35	0.03	-0.69	-0.21	-3.00	-3.00	-0.04	-1.55
17	-3.00	-1.51	-3.00	-0.89	-1.83	-1.54	-3.00	-1.80	-1.60	-0.27	-1.90	-1.15	-1.35	-2.14	-1.92	-0.35	-1.40
18	-1.80	0.27	1.19	-0.56	0.97	-0.93	1.84	-1.32	-0.44	0.35	-1.79	-1.03	-0.60	-0.84	1.32	1.01	-0.48
19	-1.16	-1.76	-2.48	-1.89	-2.74	-1.09	-1.75	-2.51	-1.91	-1.52	-1.58	-2.62	-0.07	-3.00	-3.00	-0.88	-1.82
20	-1.46	-1.16	-2.75	-1.46	-0.82	2.02	-0.07	-2.71	-0.73	-0.52	-0.03	-1.30	0.20	-3.00	-3.00	0.09	-1.51
21	-0.62	-0.49	-0.97	-0.68	1.61	-0.79	-1.97	-0.24	-2.40	1.70	-0.21	-1.22	-0.61	-3.00	-1.84	0.02	-1.16
22	-2.28	-2.39	-2.19	-1.06	-1.18	-3.00	-3.00	-1.65	-1.60	-1.42	-0.67	-1.89	-2.19	-2.35	*	-0.40	-1.04
23	-1.50	-2.31	-3.00	-1.87	0.14	-2.11	-1.12	-3.00	-0.74	-1.54	-2.21	-2.07	0.01	-2.96	-1.75	-1.93	-0.10
24	-1.60	-1.62	-2.41	-2.03	0.94	-0.39	1.61	-0.66	-2.40	-1.44	-2.91	-2.56	-0.38	-3.00	0.96	0.50	1.44

Child	SV	FG	DC	CPr	MAc	FI	LTS	MFP	GRA	BMC	PPr	SPr	OPr	PrVC	KIN	SWB	PRN
25	0.51	-0.23	0.67	-0.17	-1.32	0.45	-0.15	-3.00	-1.25	1.04	-1.68	-0.41	0.35	-3.00	-0.81	-2.77	-1.37
26	-1.39	0.80	-0.19	0.60	-2.25	0.63	0.59	-1.15	-0.09	1.91	-0.29	-0.40	-0.70	-3.00	0.53	-3.00	-1.04
27	-0.66	-1.25	-1.67	-1.36	1.02	-0.71	1.00	-2.51	-1.47	-0.22	-1.14	-0.47	0.82	-3.00	-2.68	0.72	0.77
28	-1.52	-1.53	-2.87	-2.02	-2.30	-0.94	-0.77	-2.18	-0.74	-1.70	-2.64	-1.55	-1.95	-2.96	-1.13	-1.21	-2.08
29	-0.18	-1.85	-3.00	-0.53	-2.66	-1.25	0.55	-1.53	-3.00	-1.02	-3.00	-2.79	0.11	-3.00	-2.45	-1.02	-0.17
30	-0.73	-1.58	-1.52	-0.54	-0.88	-0.35	-0.63	0.64	-0.92	-1.68	-1.08	-0.65	-0.24	0.39	-3.00	0.75	-1.08
31	-1.60	-1.40	-3.00	-2.33	-3.00	0.00	0.95	-3.00	-1.66	-1.79	-2.10	-3.00	-2.62	-3.00	-1.00	-0.42	-2.21
32	-1.62	-0.91	-0.06	0.53	0.65	-0.64	-1.35	-3.00	-2.74	-0.33	0.92	-1.00	-2.38	-3.00	0.44	-3.00	-0.37
33	-1.87	-1.63	-1.31	-0.35	2.58	-1.67	-0.03	-1.10	-0.68	0.93	-0.37	-0.23	-0.35	-3.00	-0.19	0.82	-1.49
34	-1.34	-1.85	0.95	0.16	-2.93	0.80	0.15	1.05	-2.15	0.65	-0.48	-0.34	-0.16	-3.00	0.19	-1.07	-2.07
35	-2.08	-0.77	-2.30	-1.58	-2.24	-2.57	*	-0.50	-1.37	-0.61	-1.69	-0.40	0.83	-3.00	*	-1.65	-0.91
36	-2.94	-2.30	-2.44	-1.24	-1.14	-0.83	-3.00	-2.39	-1.68	-1.18	-3.00	-2.53	-2.92	-3.00	-2.65	0.55	0.95
37	-2.58	0.53	-0.72	-1.26	-1.01	-0.74	-2.21	-3.00	-1.03	-0.48	-1.24	-0.24	-1.11	-3.00	-2.36	0.32	0.36
38	-2.58	-0.71	0.93	1.66	0.83	0.53	-3.00	0.37	0.19	1.99	0.21	-0.11	-0.36	-0.87	0.01	1.01	0.70
39	0.09	-1.33	-1.02	-0.17	-2.37	1.53	-0.90	-0.24	-1.15	0.20	-0.88	-0.21	1.26	-3.00	-1.12	1.29	-0.80

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= KInesthesia, SWB= Standing and Walking Balance, PRN= Postrotary nystagmus)

* = missing scores

4.3.3.3 Partial pattern 3: Imitative disorder pattern

This pattern is characterised by poor scores in PPr and OPr, both tests in which the child has to imitate a posture, movement or sequence of movements demonstrated by the examiner, and performed without verbal cues. Difficulties in these tests indicate difficulties translating visual cues for behaviour and actions into motor acts. Analysis of the couplet of poor performance in PPr and OPr is displayed in **Table 4.23**, with 9 (n=9/39; 23%) members of the study population falling into this group. Of these members of the study population, 8 were a better fit into the generalised sensory integrative disorder group due to their generally low scores on other major areas tested **(cf Table 4.19).** The remaining child had scores indicative of a somatodyspraxia **(cf Table 4.18),** which encompasses the imitative tests of OPr and PPr too. None of the highlighted members of the study population had dysfunctional scores in PPr and OPr which could not be accounted for by the presence of another sensory integrative disorder.

Table 4.23 Partial pattern 3: Imitative disorder pattern

Child	SV	FG	DC	CPr	MAc	FI	LTS	MFP	GRA	BMC	PPr	SPr	OPr	PrVC	KIN	SWB	PRN
1	-0.91	0.76	-2.56	-3.00	-0.14	1.49	-0.70	-2.47	-1.17	-1.10	0.92	-0.72	1.16	-1.11	-1.88	-0.02	-2.35
2	-0.10	-1.26	-1.17	-0.93	-0.13	1.21	-0.75	-1.76	0.19	0.66	-0.20	-1.41	1.60	-0.39	-3.00	0.32	-1.01
3	-0.78	0.24	-1.25	-0.06	-2.28	-0.01	2.14	-1.59	-2.24	0.55	0.28	-0.03	1.51	-2.98	-1.05	0.71	-1.68
4	-1.84	-2.77	-2.92	-2.73	1.35	-1.54	-0.08	-1.42	-2.12	-0.63	-1.68	-0.96	-0.75	-3.00	-3.00	-1.85	-1.09
5	-1.40	-2.12	-3.00	-1.44	-2.02	-2.70	-3.00	-3.00	-1.80	-1.77	-2.13	-0.64	-0.85	-3.00	-3.00	-2.79	-1.01
6	-1.30	-2.30	0.63	-1.69	2.75	-1.19	-1.99	-3.00	-1.90	0.13	0.06	-2.24	0.07	-2.96	-1.71	0.45	-0.76
7	0.56	-0.22	1.93	0.76	2.23	1.89	-1.26	0.54	-0.44	0.95	-0.18	0.05	-1.55	-0.84	1.20	0.60	-0.78
8	-0.56	-0.54	-0.91	-0.74	-0.41	-1.54	-0.61	-2.93	-0.72	-0.30	-1.29	-1.38	-0.68	-1.98	-1.63	-1.24	0.15
9	0.83	1.28	0.65	1.34	2.04	0.42	1.02	-0.35	-0.60	2.23	-0.70	1.50	0.64	-1.56	-0.47	-0.11	-2.01
10	-1.51	-0.81	-3.00	-1.01	-2.81	-2.20	-3.00	-2.94	-1.16	-0.86	-1.82	-2.85	-1.38	-3.00	0.10	-1.61	-1.70
11	-3.00	-2.41	-2.89	-3.00	*	*	*		*	-0.91	-2.21	-2.64	-2.01	-3.00	*	-2.04	0.01
12	-1.62	-1.80	-3.00	-2.28	*	-3.00	-2.42	-3.00	-2.48	-1.85	-2.32	-2.88	-1.59	-1.65	-3.00	-0.71	-1.95
13	-1.78	-2.70	-3.00	-2.24	-2.46	-1.33	-2.13	-3.00	-1.54	-2.04	-3.00	-1.41	-1.55	-3.00	-1.35	-3.00	-1.01
14	-0.87	-1.02	-3.00	-0.80	-2.77	0.96	2.55	-0.12	0.33	2.37	-0.40	1.03	1.34	-1.31	0.73	2.65	-1.14
15	-2.34	-1.53	-3.00	-2.41	-1.53	-3.00	-3.00	-3.00	-2.47	-0.91	-2.85	-1.78	-0.52	-3.00	-3.00	-3.00	0.63
16	-1.02	-2.32	-2.89	-0.90	-0.42	-1.27	-1.92	-3.00	-1.40	0.35	0.03	-0.69	-0.21	-3.00	-3.00	-0.04	-1.55
17	-3.00	-1.51	-3.00	-0.89	-1.83	-1.54	-3.00	-1.80	-1.60	-0.27	-1.90	-1.15	-1.35	-2.14	-1.92	-0.35	-1.40
18	-1.80	0.27	1.19	-0.56	0.97	-0.93	1.84	-1.32	-0.44	0.35	-1.79	-1.03	-0.60	-0.84	1.32	1.01	-0.48
19	-1.16	-1.76	-2.48	-1.89	-2.74	-1.09	-1.75	-2.51	-1.91	-1.52	-1.58	-2.62	-0.07	-3.00	-3.00	-0.88	-1.82
20	-1.46	-1.16	-2.75	-1.46	-0.82	2.02	-0.07	-2.71	-0.73	-0.52	-0.03	-1.30	0.20	-3.00	-3.00	0.09	-1.51
21	-0.62	-0.49	-0.97	-0.68	1.61	-0.79	-1.97	-0.24	-2.40	1.70	-0.21	-1.22	-0.61	-3.00	-1.84	0.02	-1.16
22	-2.28	-2.39	-2.19	-1.06	-1.18	-3.00	-3.00	-1.65	-1.60	-1.42	-0.67	-1.89	-2.19	-2.35	*	-0.40	-1.04
23	-1.50	-2.31	-3.00	-1.87	0.14	-2.11	-1.12	-3.00	-0.74	-1.54	-2.21	-2.07	0.01	-2.96	-1.75	-1.93	-0.10
24	-1.60	-1.62	-2.41	-2.03	0.94	-0.39	1.61	-0.66	-2.40	-1.44	-2.91	-2.56	-0.38	-3.00	0.96	0.50	1.44

Child	SV	FG	DC	CPr	MAc	FI	LTS	MFP	GRA	BMC	PPr	SPr	OPr	PrVC	KIN	SWB	PRN
25	0.51	-0.23	0.67	-0.17	-1.32	0.45	-0.15	-3.00	-1.25	1.04	-1.68	-0.41	0.35	-3.00	-0.81	-2.77	-1.37
26	-1.39	0.80	-0.19	0.60	-2.25	0.63	0.59	-1.15	-0.09	1.91	-0.29	-0.40	-0.70	-3.00	0.53	-3.00	-1.04
27	-0.66	-1.25	-1.67	-1.36	1.02	-0.71	1.00	-2.51	-1.47	-0.22	-1.14	-0.47	0.82	-3.00	-2.68	0.72	0.77
28	-1.52	-1.53	-2.87	-2.02	-2.30	-0.94	-0.77	-2.18	-0.74	-1.70	-2.64	-1.55	-1.95	-2.96	-1.13	-1.21	-2.08
29	-0.18	-1.85	-3.00	-0.53	-2.66	-1.25	0.55	-1.53	-3.00	-1.02	-3.00	-2.79	0.11	-3.00	-2.45	-1.02	-0.17
30	-0.73	-1.58	-1.52	-0.54	-0.88	-0.35	-0.63	0.64	-0.92	-1.68	-1.08	-0.65	-0.24	0.39	-3.00	0.75	-1.08
31	-1.60	-1.40	-3.00	-2.33	-3.00	0.00	0.95	-3.00	-1.66	-1.79	-2.10	-3.00	-2.62	-3.00	-1.00	-0.42	-2.21
32	-1.62	-0.91	-0.06	0.53	0.65	-0.64	-1.35	-3.00	-2.74	-0.33	0.92	-1.00	-2.38	-3.00	0.44	-3.00	-0.37
33	-1.87	-1.63	-1.31	-0.35	2.58	-1.67	-0.03	-1.10	-0.68	0.93	-0.37	-0.23	-0.35	-3.00	-0.19	0.82	-1.49
34	-1.34	-1.85	0.95	0.16	-2.93	0.80	0.15	1.05	-2.15	0.65	-0.48	-0.34	-0.16	-3.00	0.19	-1.07	-2.07
35	-2.08	-0.77	-2.30	-1.58	-2.24	-2.57	*	-0.50	-1.37	-0.61	-1.69	-0.40	0.83	-3.00	*	-1.65	-0.91
36	-2.94	-2.30	-2.44	-1.24	-1.14	-0.83	-3.00	-2.39	-1.68	-1.18	-3.00	-2.53	-2.92	-3.00	-2.65	0.55	0.95
37	-2.58	0.53	-0.72	-1.26	-1.01	-0.74	-2.21	-3.00	-1.03	-0.48	-1.24	-0.24	-1.11	-3.00	-2.36	0.32	0.36
38	-2.58	-0.71	0.93	1.66	0.83	0.53	-3.00	0.37	0.19	1.99	0.21	-0.11	-0.36	-0.87	0.01	1.01	0.70
39	0.09	-1.33	-1.02	-0.17	-2.37	1.53	-0.90	-0.24	-1.15	0.20	-0.88	-0.21	1.26	-3.00	-1.12	1.29	-0.80

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= KInesthesia, SWB= Standing and Walking Balance, PRN= Postrotary nystagmus)

* = missing scores

4.3.3.4 Partial pattern 4: Vestibulosomatosensory processing deficit

This pattern and disorder is characterised by a correlation between low scores in PRN and the somatosensory tests (MFP, KIN, FI, GRA and LTS) (Ayres, 2004, p134). **Table 4.24** indicates the 7 members of the study population in which this particular pattern of scores is present in the highlighted blocks (n=7/39; 18%).

These members of the study population's scores could in all but one case be accounted for by a possible generalised sensory integrative disorder **(cf Table 4.19)**, which accounts for the inefficient vestibular processing as well as difficulties processing proprioceptive information. The remaining child was also highlighted in the group for a possible visuodyspraxia **(cf Table 4.17)** as well as in the partial pattern scores for a visual construction deficit **(cf Table 4.22)**. It would seem that this child has difficulty in many areas affected by sensory integration. No child had a score pattern that could be solely accounted for by vestibulosomatosensory processing difficulty without other sensory integrative difficulties.

Table 4.24 Partial pattern 4: Vestibulosomatosensory processing deficit

Child	SV	FG	DC	CPr	MAc	FI	LTS	MFP	GRA	BMC	PPr	SPr	OPr	PrVC	KIN	SWB	PRN
1	-0.91	0.76	-2.56	-3.00	-0.14	1.49	-0.70	-2.47	-1.17	-1.10	0.92	-0.72	1.16	-1.11	-1.88	-0.02	-2.35
2	-0.10	-1.26	-1.17	-0.93	-0.13	1.21	-0.75	-1.76	0.19	0.66	-0.20	-1.41	1.60	-0.39	-3.00	0.32	-1.01
3	-0.78	0.24	-1.25	-0.06	-2.28	-0.01	2.14	-1.59	-2.24	0.55	0.28	-0.03	1.51	-2.98	-1.05	0.71	-1.68
4	-1.84	-2.77	-2.92	-2.73	1.35	-1.54	-0.08	-1.42	-2.12	-0.63	-1.68	-0.96	-0.75	-3.00	-3.00	-1.85	-1.09
5	-1.40	-2.12	-3.00	-1.44	-2.02	-2.70	-3.00	-3.00	-1.80	-1.77	-2.13	-0.64	-0.85	-3.00	-3.00	-2.79	-1.01
6	-1.30	-2.30	0.63	-1.69	2.75	-1.19	-1.99	-3.00	-1.90	0.13	0.06	-2.24	0.07	-2.96	-1.71	0.45	-0.76
7	0.56	-0.22	1.93	0.76	2.23	1.89	-1.26	0.54	-0.44	0.95	-0.18	0.05	-1.55	-0.84	1.20	0.60	-0.78
8	-0.56	-0.54	-0.91	-0.74	-0.41	-1.54	-0.61	-2.93	-0.72	-0.30	-1.29	-1.38	-0.68	-1.98	-1.63	-1.24	0.15
9	0.83	1.28	0.65	1.34	2.04	0.42	1.02	-0.35	-0.60	2.23	-0.70	1.50	0.64	-1.56	-0.47	-0.11	-2.01
10	-1.51	-0.81	-3.00	-1.01	-2.81	-2.20	-3.00	-2.94	-1.16	-0.86	-1.82	-2.85	-1.38	-3.00	0.10	-1.61	-1.70
11	-3.00	-2.41	-2.89	-3.00	*	*	*		*	-0.91	-2.21	-2.64	-2.01	-3.00	*	-2.04	0.01
12	-1.62	-1.80	-3.00	-2.28	*	-3.00	-2.42	-3.00	-2.48	-1.85	-2.32	-2.88	-1.59	-1.65	-3.00	-0.71	-1.95
13	-1.78	-2.70	-3.00	-2.24	-2.46	-1.33	-2.13	-3.00	-1.54	-2.04	-3.00	-1.41	-1.55	-3.00	-1.35	-3.00	-1.01
14	-0.87	-1.02	-3.00	-0.80	-2.77	0.96	2.55	-0.12	0.33	2.37	-0.40	1.03	1.34	-1.31	0.73	2.65	-1.14
15	-2.34	-1.53	-3.00	-2.41	-1.53	-3.00	-3.00	-3.00	-2.47	-0.91	-2.85	-1.78	-0.52	-3.00	-3.00	-3.00	0.63
16	-1.02	-2.32	-2.89	-0.90	-0.42	-1.27	-1.92	-3.00	-1.40	0.35	0.03	-0.69	-0.21	-3.00	-3.00	-0.04	-1.55
17	-3.00	-1.51	-3.00	-0.89	-1.83	-1.54	-3.00	-1.80	-1.60	-0.27	-1.90	-1.15	-1.35	-2.14	-1.92	-0.35	-1.40
18	-1.80	0.27	1.19	-0.56	0.97	-0.93	1.84	-1.32	-0.44	0.35	-1.79	-1.03	-0.60	-0.84	1.32	1.01	-0.48
19	-1.16	-1.76	-2.48	-1.89	-2.74	-1.09	-1.75	-2.51	-1.91	-1.52	-1.58	-2.62	-0.07	-3.00	-3.00	-0.88	-1.82
20	-1.46	-1.16	-2.75	-1.46	-0.82	2.02	-0.07	-2.71	-0.73	-0.52	-0.03	-1.30	0.20	-3.00	-3.00	0.09	-1.51
21	-0.62	-0.49	-0.97	-0.68	1.61	-0.79	-1.97	-0.24	-2.40	1.70	-0.21	-1.22	-0.61	-3.00	-1.84	0.02	-1.16
22	-2.28	-2.39	-2.19	-1.06	-1.18	-3.00	-3.00	-1.65	-1.60	-1.42	-0.67	-1.89	-2.19	-2.35	*	-0.40	-1.04
23	-1.50	-2.31	-3.00	-1.87	0.14	-2.11	-1.12	-3.00	-0.74	-1.54	-2.21	-2.07	0.01	-2.96	-1.75	-1.93	-0.10
24	-1.60	-1.62	-2.41	-2.03	0.94	-0.39	1.61	-0.66	-2.40	-1.44	-2.91	-2.56	-0.38	-3.00	0.96	0.50	1.44

Child	SV	FG	DC	CPr	MAc	FI	LTS	MFP	GRA	BMC	PPr	SPr	OPr	PrVC	KIN	SWB	PRN
25	0.51	-0.23	0.67	-0.17	-1.32	0.45	-0.15	-3.00	-1.25	1.04	-1.68	-0.41	0.35	-3.00	-0.81	-2.77	-1.37
26	-1.39	0.80	-0.19	0.60	-2.25	0.63	0.59	-1.15	-0.09	1.91	-0.29	-0.40	-0.70	-3.00	0.53	-3.00	-1.04
27	-0.66	-1.25	-1.67	-1.36	1.02	-0.71	1.00	-2.51	-1.47	-0.22	-1.14	-0.47	0.82	-3.00	-2.68	0.72	0.77
28	-1.52	-1.53	-2.87	-2.02	-2.30	-0.94	-0.77	-2.18	-0.74	-1.70	-2.64	-1.55	-1.95	-2.96	-1.13	-1.21	-2.08
29	-0.18	-1.85	-3.00	-0.53	-2.66	-1.25	0.55	-1.53	-3.00	-1.02	-3.00	-2.79	0.11	-3.00	-2.45	-1.02	-0.17
30	-0.73	-1.58	-1.52	-0.54	-0.88	-0.35	-0.63	0.64	-0.92	-1.68	-1.08	-0.65	-0.24	0.39	-3.00	0.75	-1.08
31	-1.60	-1.40	-3.00	-2.33	-3.00	0.00	0.95	-3.00	-1.66	-1.79	-2.10	-3.00	-2.62	-3.00	-1.00	-0.42	-2.21
32	-1.62	-0.91	-0.06	0.53	0.65	-0.64	-1.35	-3.00	-2.74	-0.33	0.92	-1.00	-2.38	-3.00	0.44	-3.00	-0.37
33	-1.87	-1.63	-1.31	-0.35	2.58	-1.67	-0.03	-1.10	-0.68	0.93	-0.37	-0.23	-0.35	-3.00	-0.19	0.82	-1.49
34	-1.34	-1.85	0.95	0.16	-2.93	0.80	0.15	1.05	-2.15	0.65	-0.48	-0.34	-0.16	-3.00	0.19	-1.07	-2.07
35	-2.08	-0.77	-2.30	-1.58	-2.24	-2.57	*	-0.50	-1.37	-0.61	-1.69	-0.40	0.83	-3.00	*	-1.65	-0.91
36	-2.94	-2.30	-2.44	-1.24	-1.14	-0.83	-3.00	-2.39	-1.68	-1.18	-3.00	-2.53	-2.92	-3.00	-2.65	0.55	0.95
37	-2.58	0.53	-0.72	-1.26	-1.01	-0.74	-2.21	-3.00	-1.03	-0.48	-1.24	-0.24	-1.11	-3.00	-2.36	0.32	0.36
38	-2.58	-0.71	0.93	1.66	0.83	0.53	-3.00	0.37	0.19	1.99	0.21	-0.11	-0.36	-0.87	0.01	1.01	0.70
39	0.09	-1.33	-1.02	-0.17	-2.37	1.53	-0.90	-0.24	-1.15	0.20	-0.88	-0.21	1.26	-3.00	-1.12	1.29	-0.80

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification,
LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis,
SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= KInesthesia, SWB= Standing and Walking Balance,
PRN= Postrotary nystagmus)

* = missing score

4.4 Hand skills

4.4.1 Preferred hand use

Table 4.25 shows the preferred hand use of the 39 members of the study population in the study population. 35 (90%) of members of the study population used their right hand as their dominant or preferred hand. There were no members of the study population who were left dominant, but 4 (10%) members of the study population used both hands during performance in the SIPT, specifically in DC.

Table 4.25 Preferred hand use

Preferred hand use (n=39)	Number
Left	0
Right	35
Both	4

4.4.2 Skilled hand use in SIPT

The somatosensory tests in the SIPT require the skilled use of both upper limbs to achieve a typical or above average score. MFP, KIN, FI, GRA and LTS require perception of somatosensory information without the assistance of vision, relying totally on the processing ability of the tactile and proprioceptive systems (discussed in chapter 2). **Table 4.26** represents the minimum, median and maximum SD scores for all participants in SIPT tests where different, simultaneous actions are required from each hand and where the somatosensory processing from each hand and arm is evaluated.

In MFP part 1, there is 3.98 SD difference in scores between the minimum and maximum score for accuracy in interpreting tactile information received by the right hand. Many members of the study population scored poorly in this test, resulting in a mean score in the mildly dysfunctional range. Accuracy of interpretation of information from the left hand showed a 4.25 SD between the minimum and maximum scores, due to some members of the study population performing severely poorly and others performing typically for their age. The median score for left hand accuracy was in the mildly dysfunctional range. MFP part 2 is a more complex test, administered to members of the study population over the age of 4. In this test, tactile information received from one hand has to be matched with tactile information from the other hand, without the assistance of vision. There was a 4.37 SD and 3.94 SD difference between the minimum and maximum scores in right and left hand accuracy respectively. The median score for right hand accuracy was in the range of typical performance, while the left hand scores were mildly dysfunctional. The large difference between minimum and maximum scores indicate a significant difference in somatosensory processing abilities of members of the study population, with many members of the study population testing in the dysfunctional range, but some having had typical functioning.

KIN makes use of tactile and proprioceptive processing. The range of scores between minimum and maximum scores achieved was 4.31 SD for right accuracy and 4.51 SD for left accuracy. The median scores of the right and left hand were in the mildly dysfunctional range.

FI relies on the processing of tactile and proprioceptive information to identify which finger has been touched by the examiner, with the child's vision occluded. The maximum score on the right hand was in the above average range, indicating very accurate processing and reproduction of information. The range of scores however was 4.89 SD, indicating that while some members of the study population had above average functioning and abilities in processing and interpreting this information, others had severe difficulty. The minimum and maximum accuracy scores for the left hand differed by 4.62 SD. The mean scores for right and left accuracy were in the typical range.

GRA is a more complex test, where tactile information needs to be processed and a motor act planned to reproduce the sensation received. The range between minimum and maximum scores was 3.27 and 4.16 SD for the left and right hands respectively, with the median score for both these being in the mildly dysfunctional range. There were members of the study population who received scores in the severely dysfunctional range in this test, with some typical and above average scores occurring too.

The range of scores between minimum and maximum on LTS was 5.10 SD for right accuracy and 5.26 SD for left accuracy. There was a large distribution of scores between members of the study population with severely dysfunctional processing and members of the study population with advanced processing of tactile and proprioceptive input in this test. Median scores were in the typical range.

MAc had the largest spread of scores between minimum and maximum scores achieved, and showed a large variability in the members of the study population's abilities. Some members of the study population had advanced functioning, with the maximum scores being 2.93 SD and 3.00 SD for right and left accuracy respectively. Others had severe difficulties, refusing to participate in the test or achieving scores of -3.00 SD for left and right accuracy. The median scores were in the typical functioning range.

Table 4.26 SD range of scores for tests requiring skilled use of upper limbs

		Minimum	Median	Maximum
MFP 1	right accuracy	-3.00	-1.13	0.98
	left accuracy	-3.00	-1.40	1.25
MFP 2	right accuracy	-3.00	-0.75	1.37
	left accuracy	-2.72	-1.16	1.22
KIN	right accuracy	-3.00	-1.37	1.31
	left accuracy	-3.00	-1.40	1.51
FI	right accuracy	-3.00	-0.73	1.89
	left accuracy	-3.00	-0.23	1.62
GRA	right accuracy	-2.65	-1.20	0.62
	left accuracy	-2.97	-1.15	1.19
LTS	right accuracy	-3.00	-0.67	2.10
	left accuracy	-3.00	-0.78	2.26
MAc	right accuracy	-3.00	-0.97	2.93
	left accuracy	-3.00	-0.90	3.00

4.4 BEHAVIOURAL RESPONSES TO TESTING

Behaviour during testing was noted on the SIPT test booklet and transferred to the data sheet for processing and analysis. These behaviours are tabulated with the frequency of occurrence in 39 test subjects in **Table 4.27**. Many of these were behaviours associated with a state of stress (change in respiratory rate (3%), need to urinate (44%) or defecate (18%), crying (8%), anxiety (41%), hypervigilance (5%), verbal outbursts (8%) and running away (39%) (Discussed in **Section 2.5**). Behaviours associated with a fright, fight or flight response to an emotionally stressful situation or a situation perceived as threatening were also noted here, specifically a change in respiratory rate (3%), hypervigilance (5%), verbal outbursts (8%), avoidant behaviour (39%) and running away (15%). As discussed in **Section 2.5**, members of the study population may respond to a stressful situation by entering a dissociated state, or "shut down" (18%). A "shut down" occurs when the central nervous system is bombarded with sensory information which it is not able to process efficiently, and enters a protective state mimicking hyporesponsiveness, in which the child no longer responds to information from his environment (Bar-Shalita *et al*, 2005, p149) (discussed in **Section 2.1.3.2**). Some members of the study population found the demands of the SIPT so draining, that they lay on their arms during the test (26%) or fell asleep soon after completion (21%). A total of 69% of members of the study population experienced a degree of motor agitation during the test administration, and wriggled significantly in their seats. This became more evident in the later stages of the test, when there had been a loading effect of stimuli to the central nervous system due to the sensory processing and performance demands placed on the child. 21 % of members of the study population changed their preferred hand during test administration, in tasks where they were required to reproduce a two dimensional line drawing (DC) or trace along a pre printed path with a pen (MAc). These were members of the study population where the chemotherapy was being administered through a peripheral line in their preferred or dominant hand, or where chemotherapy had been administered through that hand for a period of time and recently changed to another site. "Other" behaviour included a change in perceived body temperature, also possibly due to a stress reaction to the test, scratching and rubbing the hands during administration of the somatosensory tests, biting or hitting the shield used to occlude vision, and hitting out at the examiner.

Table 4.27 Behavioural Responses to Testing

Behaviour	Number of children (n=39)
Yawning	9 (23%)
Change in respiratory rate	1 (3%)
Need to urinate	17 (44%)
Need to defecate	7 (18%)
Sleeping soon after completion	8 (21%)
Crying	3 (8%)
Anxiety	16 (41%)
Lying on arms	10 (26%)
Irritability	13 (33%)
Hypervigilance	2 (5%)
Drop in mood	19 (49%)
"Shut down”	7 (18%)
Verbal outbursts	3 (8%)
Avoidant behaviour	15 (39%)
Running away	6 (15%)
Change in preferred hand use	8 (21%)
Wriggling	27 (69%)
Other	13 (33%)

4.5 CLINICAL OBSERVATIONS

Clinical observations of prone extension, supine flexion and ocular pursuits, provide us with additional information on the functioning of the vestibular system and the processing of vestibular information (Bundy *et al*, 2002, p176, 177; Ayres, 2005, p63). Normal processing of vestibular information, will enable the child to follow the path of a moving object across all visual fields (ocular pursuits), maintain a prone position, with upper limbs, lower limbs and neck extended and off the supporting surface, as if he were an aeroplane (prone extension) and curl up into a tight ball on his back, tucking his arms, legs and head in without having to hold his posture by wrapping his arms around his legs (supine flexion). **Table 4.28** visually represents the prevalence of members of the study population with poor, slightly deficient and adequate performance in these three clinical observations.

Table 4.28 Clinical Observations (n=38)

	Prone extension	Supine flexion	Ocular pursuits
Poor	19 (50%)	17 (45%)	11 (29%)
Slightly deficient	16 (42%)	19 (50%)	16 (42%)
Adequate	3 (8%)	2 (5%)	11 (29%)

4.6 CHEMOTHERAPY ADMINISTRATION METHOD

Chemotherapy is mostly administered intravenously. There are incidences if intrathecal, intramuscular and oral administration in the treatment of specific types of cancer. The SIPT requires skilled use of the hands and upper limbs, in hand manipulation and processing of tactile and proprioceptive information from receptors in the upper limbs. A total of 28 members of the study population received chemotherapy through peripheral lines, in their left upper limb, right upper limb or both. Seventeen members of the study population had central lines inserted for administration of chemotherapy **(cf Figure4.4).**

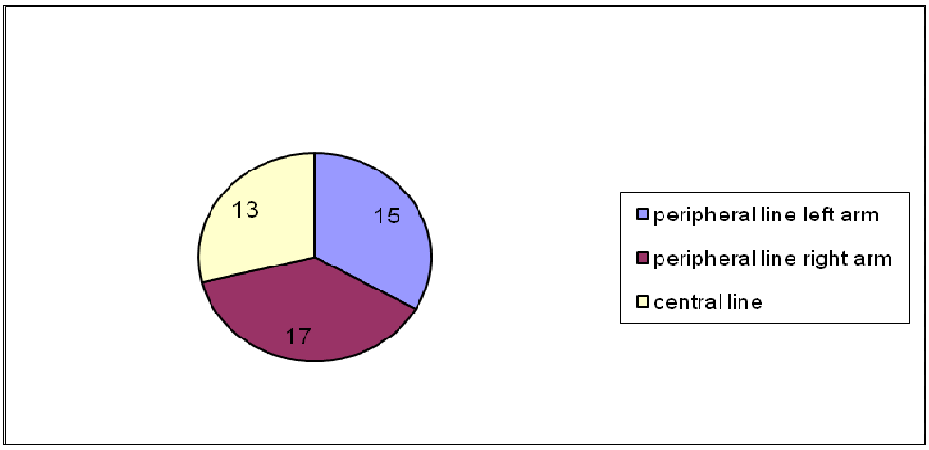


Figure 4.4 Administration method

Seventeen (44%) members of the study population in the study population received chemotherapy in their preferred or dominant hand or arm at the time of testing, or there was evidence that a drip had been inserted there (noted by dark discolouration of skin around the previous administration site and areas of noticeable skin damage where chemotherapeutic agents had leaked into tissue). Information regarding the insertion of a central line was collected from the treatment notes in the hospital file. Twenty-two (56%) of members of the study population had received administration of chemotherapy through a central line or a peripheral line in the non-preferred or non-dominant hand **(cf Table 4.29).**

Table 4.29 Intravenous Chemotherapy administration method and site

Administration method and site	Number
Peripheral line in preferred hand/arm	17 (44%)
Peripheral line in non-preferred hand/arm or central line only	22 (56%)

Multiple sites for chemotherapy administration were noted in 7 (18%) members of the study population. A peripheral line and a central line was used in 5 members of the study population, due to central lines being inserted after treatment had started some systemic chemotherapy having being administered through a peripheral line first, or incidences when a central line became dislodged or infected, making it impossible for chemotherapy to be administered that way and necessitating the use of a peripheral line. Three members of the study population had previous administrations peripherally in both upper limbs, with the site being altered due to tissue damage or venous integrity **(cf Table 4.30).**

Table 4.30 Multiple sites of Chemotherapy administration

Administration site	Number of Individuals
Left arm and right arm	3
Left arm and central line	2
Right arm and central line	2

The SIPT scores for tests involving skilled use and efficient processing of somatosensory information from both upper limbs, for the 17 members of the study population receiving chemotherapy through a peripheral line in their preferred hand **(cf Table 4.29)** are reported in **Table 4.31**. Twelve of the 17 (71%) had MFP scores in the dysfunctional range, with 8 (47%) of these being indicative of a severe dysfunction. Ten (59%) of the subgroup experienced some degree of dysfunction in proprioceptive processing, indicated by the KIN scores. The ability to determine the site of tactile input (FI) remained largely intact, with 10 (59%) of the members of the study population functioning typically in this subtest. LTS had an almost even split between dysfunctional and functional ranges, with 9 (%) and 10 (59%) members of the study population receiving scores in the dysfunctional and functional ranges respectively. LTS and FI rely on the accurate perception of the site of proprioceptive input (a touch) to an area on the hand or forearm, often the same areas in which venipuncture occurs to insert a peripheral line, or a finger prick is done to analyse blood. **Figure 4.5** provides a graphic representation of the distribution of scores in levels of function and dysfunction for each subtest.

Table 4.31 SD score range for 17 members of the study population receiving chemotherapy through peripheral line in preferred hand.

Test	Severe dysfunction -3.0 SD to-2.5 SD	Definite dysfunction -2.5 SD to -2.0 SD	Mild dysfunction -2.0 SD to -1.0SD	Typical performance -1.0 SD to +1.0 SD	Above average +1.0 SD to +2.0 SD	Advanced function +2.0 SD to +3.0 SD
MFP (n=17)	8 (47%)	0	4 (24%)	5 (29%)	0	0
KIN (n=16)	4 (25%)	2 (13%)	4 (25%)	6 (38%)	0	0
FI (n=17)	3 (18%)	2 (12%)	2 (12%)	10 (59%)	0	0
GRA (n=17)	1 (6%)	4 (24%)	7 (41%)	5 (29%)	0	0
LTS (n=17)	5 (29%)	2 (12%)	2 (12%)	6 (35%)	2	0

(MFP= Manual Form Perception, KIN= Kinaesthesia, FI = Finger Identification, GRA= graphesthesia , LTS= Localisation of Tactile Stimuli)

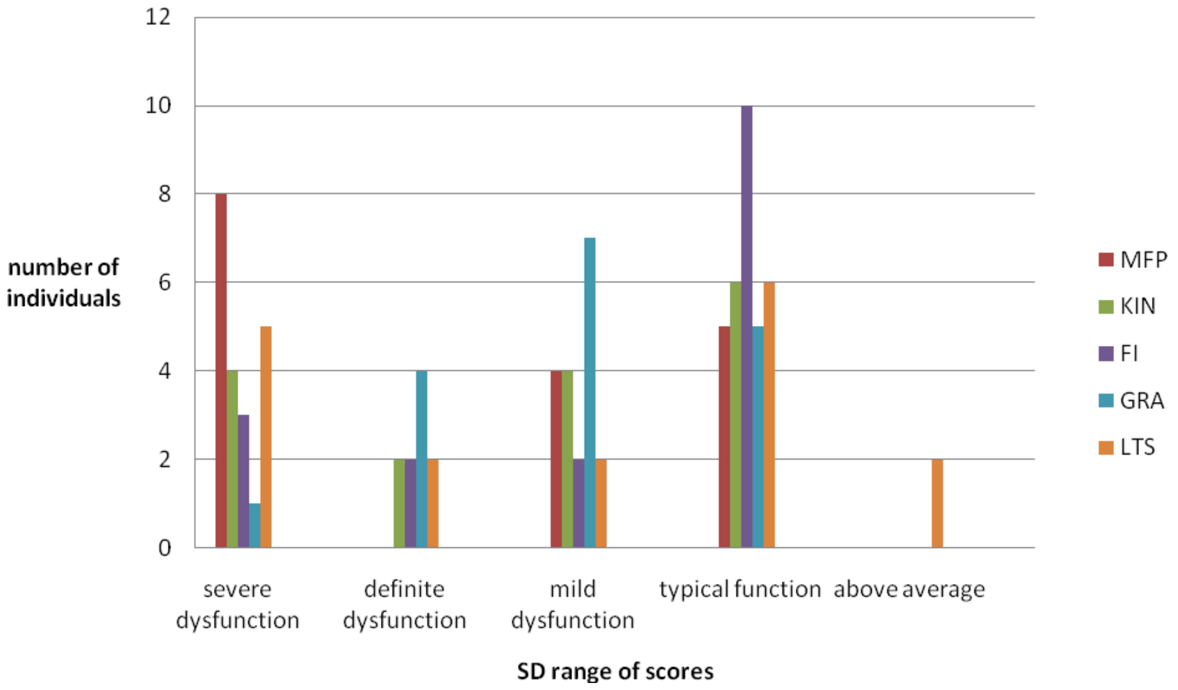


Figure 4.5 Range of function and dysfunction in tactile processing tests for members of the study population receiving intravenous chemotherapy in preferred hand

4.7 CHEMOTHERAPY

The number of individuals receiving each type of chemotherapy is represented in **Table 4.32.** These drugs are chosen according to protocols decided on by the paediatric oncologist in charge of the treating facility, in accordance with national and international standards of treatment **(cf Section 2.4; Section 3.3 paragraph 2).**

Vincristine (72%), Doxorubicin (64%), Cyclophosphamide (51%), Etoposide (49%), systemic Cytosar (46%), Daunorubicin (46%), systemic Methotrexate (36%)intrathecal Methotrexate (41%), Prednisone (39%), Mesna (36%), intrathecal Cytosar (33%), intrathecal Hydrocortisone (33%), Dexamethasone (31%), Ifosfamide (28%), L-Aspsraginase (28%), 6-Thioguanine (28%), Actinomycin (26%), and Leukovorin (26%) were used in more than 25 % of the study population.

Literature provides information on neurocognitive, neurobehavioural and systemic late effects of childhood cancer treatment with Cyclophosphamide, Cytarabine, systemic and intrathecal Methotrexate, intrathecal Cytosar, Intrathecal Hydrocortisone, L-Aspsraginase, Vincristine, Prednisone, Doxorubicin and Dexamethasone **(cf Section 2.5)**.

Table 4.32 Chemotherapy Administered

Drug	Number of individuals (n=39)	Percentage
Carboplatin	6	15%
Cisplatin	3	8%
Cyclophosphamide	20	51%
Cytosar	18	46%
Actinomycin	10	26%
Daunorubicin	18	46%
Dexamethasone	12	31%
Doxorubicin	25	64%
Etoposide	19	49%
Ifosfamide/ Ifex/ IFF	11	28%
L-Asparaginase	11	28%
Mercaptopurine	8	21%
Methotrexate	14	36%
Prednisone	15	39%
ATRA	1	3%
Vincristine	28	72%
Vinblastine	2	5%
6-Thioguanine	11	28%
5-FU	1	3%
Intrathecal Methotrexate	16	41%
Intrathecal Cytosar	13	33%
Intrathecal Hydrocortisone	13	33%
Mesna	14	36%
Leukovorin	10	26%
Allopurinol	2	5%
Chloromex	1	3%
Pyroxidine	3	8%
Procarbazine	1	3%
VM26	1	3%
Polygam	1	3%
Novantrone	1	3%
INH	1	3%

4.7.1 Cyclophosphamide

The minimum, median and maximum scores on all subtests of the SIPT are reported in **Table 4.33**.

In tests of form and space perception, visual motor construction and construction, the minimum scores indicated a severe dysfunction. Median scores were indicative of a mild dysfunction, except for CPr which was in the average range. Some members of the study population had abilities in form and space perception which were typical compared to normally developing peers, with average scores being achieved in SV, and MAc. There were scores achieved in the above average range in some subtests, including FG, DC and CPr, indicating above average functioning and skill development in these areas.

Tactile discrimination scores indicated that some members of the study population had severe dysfunction in this area, with all subtests having received a minimum score of -3SD. The median scores of MFP and GRA were in the definite dysfunction and mild dysfunction range respectively. LTS and FI obtained median scores in the average range. There were scores indicative of advanced functioning in LTS, and above functioning in FI.

PrVC received very low scores, with the minimum and median scores being in the severely dysfunctional range.

The minimum scores were also in the severely dysfunctional range in BMC, SPr, PPr and OPr. OPr was the practic test in which the highest scores were obtained, with the median score being in the typical range and the maximum score indicating above average functioning. SPr and PPr had median scores in the below average range.

Table 4.33 Range of SIPT scores of members of the study population receiving Cyclophosphamide (n=20)

	minimum	median	maximum
Form and space perception, visual motor construction & construction			
SV	-3	-1.55	0.83
FG	-2.7	-1.25	1.28
DC	-3	-1.93	1.19
CPr	-3	0.86	1.34
MAc	-3	-1.06	0.77
Tactile Discrimination			
FI	-3	-0.79	1.49
LTS	-3	-0.63	2.55
MFP	-3	-2.11	0.62
GRA	-3	-1.47	0.33
Praxis			
BMC	-2.04	-0.59	2.37
SPr	-3	-1.12	1.5
PPr	-3	-1.11	0.92
OPr	-2.6	-0.6	1.6
PrVC	-3	-2.99	0.39
Vestibular and Proprioceptive processing			
KIN	-3	-1.49	1.32
SWB	-3	-0.25	2.65
PRN	-2.35	-1.06	0.77

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= Kinaesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

4.7.2 Cytarabine

Table 4.34 visually represents the minimum, median and maximum scores in the SIPT domains.

Tests of form and space perception, visual motor construction and construction indicated a severe dysfunction, with the minimum, median and maximum scores in SD being in a dysfunctional range. FG, DC, CPr and MAc had scores in the minimum and median range indicating dysfunction, with the median scores in DC and MAc being on the low end of typical performance.

Tests of tactile discrimination also showed minimum and median scores in the dysfunctional range, with median scores of LTS and FI being on the low end of typical performance. There were indications of above average functioning in FI, MFP and LTS.

The minimum scores in tests of praxis were in the severely dysfunctional range, with Pr VC being the most poorly performed. Median scores in SPr and PPr were in the mild dysfunction range.

Vestibular and proprioceptive processing seemed to be severely affected in this population, with KIN, SWB and PRN obtaining minimum scores in the severely dysfunctional range. Median scores for KIN and PRN were also indicative of mild dysfunction. The maximum score for PRN, in the above average range was indicative of a dysfunction in processing vestibular information.

Table 4.34 Range of SIPT scores of members of the study population receiving Cytarabine (n=18)

	minimum	**Median**	**maximum**
Form and space perception, visual motor construction & construction			
SV	-3.00	-1.09	-1.00
FG	-2.70	-1.62	0.76
DC	-3.00	-2.46	0.95
CPr	-3.00	-0.97	0.16
MAc	-2.93	-0.88	2.58
Tactile Discrimination			
FI	-2.70	-0.83	1.49
LTS	-3.00	-0.70	2.55
MFP	-3.00	-2.43	1.05
GRA	-3.00	-1.47	0.33
Praxis			
BMC	-2.04	-0.88	2.37
SPr	-2.85	-1.30	1.03
PPr	-3.00	-1.21	0.92
OPr	-2.92	-0.29	1.60
PrVC	-3.00	-3.00	0.39
Vestibular and Proprioceptive processing			
KIN	-3.00	-1.88	0.96
SWB	-3.00	-0.03	2.65
PRN	-2.35	-1.04	1.44

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= Kinaesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

4.7.3 Intrathecal Hydrocortisone

Table 4.35 represents scores obtained by members of the study population receiving intrathecal hydrocortisone.

Tests of Form and space perception, visual motor construction & construction obtained minimum scores indicating severe dysfunction in SV, DC, CPr and MAc, with DC indicating a score in the definite dysfunction range. Median scores in this section indicate dysfunction in FG and DC, with SV and CPr being low typical. There was evidence of above average ability in DC and advanced functioning in MAc.

Tactile discrimination tests showed instances of definite to severe dysfunction in all tests on the one side of the spectrum, and above average and advanced functioning in discriminating FI and LTS respectively on the other. Median scores in MFP and GRA indicated a definite and mild dysfunction.

Practic abilities in SPr, PPr and PrVC had minimum and median scores indicating varying levels of dysfunction. BMC had minimum scores in the definite dysfunction range, and a maximum score which indicated advanced functioning. OPr and SPR had maximum scores above average.

Vestibular and proprioceptive functioning was severely affected in some members of the study population receiving intrathecal hydrocortisone, with minimum scores in SWB and PRN being in the definite dysfunctional range, and KIN obtaining a score indicating a severe dysfunction. The maximum score for PRN indicated a dysfunction too.

Table 4.35 Range of SIPT scores of members of the study population receiving Intrathecal Hydrocortisone (n=13)

	minimum	Median	maximum
Form and space perception, visual motor construction & construction			
SV	-3.00	-0.91	0.56
FG	-2.41	-1.26	0.76
DC	-3.00	-2.56	1.93
CPr	-3.00	-0.93	0.76
MAc	-3.00	-0.27	2.58
Tactile Discrimination			
FI	-2.20	-0.55	1.89
LTS	-3.00	-0.32	2.55
MFP	-3.00	-2.47	0.54
GRA	-3.00	-1.16	0.33
Praxis			
BMC	-1.79	-0.30	2.37
SPr	-3.00	-1.38	1.03
PPr	-3.00	-1.14	0.92
OPr	-2.62	-0.35	1.60
PrVC	-3.00	-3.00	-0.39
Vestibular and Proprioceptive processing			
KIN	-3.00	-1.31	1.20
SWB	-2.04	-0.02	2.65
PRN	-2.35	-1.01	1.44

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= Kinaesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

4.7.4 Intrathecal Methotrexate

Table 4.36 visually represents the minimum, median and maximum SIPT scores for members of the study population receiving intrathecal methotrexate.

Tests of Form and space perception, visual motor construction & construction, showed minimum scores in the severely dysfunctional range for all tests except DC, which had a minimum score indicating a definite dysfunction. Median scores indicated dysfunction in FG and DC, with typical functioning in SV, CPr and MAc. Above average functioning was evident in the maximum scores obtained in DC and the advanced functioning in MAc.

Tactile discrimination minimum scores indicated severe dysfunction in all aspects. Median scores in MFP and GRA remained in the dysfunctional range. Above average functioning was noted in MFP, while tests of FI and LTS obtained scores in the advanced functioning range.

Tests of praxis obtained minimum scores indicating various levels of dysfunction, with, SPr, PPr and PrVC being the most severely affected, closely followed by OPr. Median scores for SPr and PrVC indicated dysfunction, while scores for BMC, PPr and OPr were in the range of typical performance. Advanced functioning was noted in the maximum score obtained in BMC, and above average functioning evident in SPr and OPr.

Vestibular and proprioceptive functioning indicated difficulties in performance of tests, with KIN and PRN tests obtaining minimum and median scores indicating a level of dysfunction. SWB had a minimum score in the range of severe dysfunction. Advanced functioning was indicated in SWB, with the maximum score obtained being in this range. There was also evidence of above average functioning in KIN, indicated by the maximum score in this test.

Table 4.36 Range of SIPT scores of members of the study population receiving Intrathecal Methotrexate (n=16)

	minimum	Median	maximum
Form and space perception, visual motor construction & construction			
SV	-3.00	-0.89	0.56
FG	-2.41	-1.25	0.76
DC	-3.00	-2.11	1.93
CPr	-3.00	-0.86	0.76
MAc	-3.00	-0.82	2.58
Tactile Discrimination			
FI	-3.00	-0.35	2.02
LTS	-3.00	-0.61	2.55
MFP	-3.00	-2.11	1.05
GRA	-3.00	-1.16	0.33
Praxis			
BMC	-1.79	-0.41	2.37
SPr	-3.00	-1.26	1.03
PPr	-3.00	-0.78	0.92
OPr	-2.62	-0.29	1.60
PrVC	-3.00	-3.00	0.39
Vestibular and Proprioceptive processing			
KIN	-3.00	-1.84	1.20
SWB	-3.00	0.00	2.65
PRN	-2.35	-1.11	0.77

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= Kinaesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

4.7.5 Intrathecal Cytosar

Table 4.37 indicates scores obtained for members of the study population receiving intrathecal cytosar.

Tests of Form and space perception, visual motor construction & construction, showed minimum scores in the severe or definite dysfunction range for all tests in this domain. Median scores indicated milder levels of dysfunction in all subtests of Form and space perception, visual motor construction & construction. Above average functioning was evident in the maximum scores obtained in DC and the advanced functioning in MAc.

Tactile discrimination minimum scores indicated severe dysfunction in all tests. Median scores in MFP and GRA remained in the dysfunctional range. Above average functioning was noted in MFP and FI, LTS obtained a score in the advanced functioning range.

Tests of praxis obtained minimum scores indicating various levels of dysfunction, with, SPr, PPr and PrVC being the most severely affected, closely followed by OPr. Median scores for SPr, PPr and PrVC indicated dysfunction, while scores for BMC and OPr were in the range of typical performance. Advanced functioning was noted in the maximum score obtained in BMC, and above average functioning evident in SPr and OPr.

Vestibular and proprioceptive functioning indicated difficulties in performance of tests, with KIN and PRN tests obtaining minimum and median scores indicating a level of dysfunction. SWB had a minimum score in the range of severe dysfunction. Advanced functioning was indicated in SWB, with the maximum score obtained being in this range. There was also evidence of above average functioning in KIN, and PRN indicated by the maximum scores obtained. The above average function in PRN was indicative of a dysfunction in vestibular processing.

Table 4.37 Range of SIPT scores of members of the study population receiving Intrathecal Cytosar (n=15)

	minimum	Median	maximum
Form and space perception, visual motor construction & construction			
SV	-2.34	-1.34	0.56
FG	-2.70	-1.53	-0.22
DC	-3.00	-2.89	1.93
CPr	-2.41	-1.01	0.76
Mac	-3.00	-1.53	2.23
Tactile Discrimination			
FI	-3.00	-0.71	2.02
LTS	-3.00	-0.63	2.55
MFP	-3.00	-2.51	1.05
GRA	-3.00	-1.54	0.33
Praxis			
BMC	-2.04	-0.86	2.37
SPr	-3.00	-1.22	1.03
PPr	-3.00	-1.14	0.03
OPr	-2.62	-0.38	1.34
PrVC	-3.00	-3.00	0.39
Vestibular and Proprioceptive processing			
KIN	-3.00	-1.84	1.20
SWB	-3.00	-0.04	2.65
PRN	-2.21	-1.08	1.44

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= Kinaesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

4.7.6 L-asparaginase

Scores for members of the study population receiving L-asparaginase are visually represented in **Table 4.38.**

Tests of Form and space perception, visual motor construction & construction, showed minimum scores in the severely dysfunctional range for all tests except FG and MAc, which had minimum scores indicating a definite dysfunction. Median scores indicated dysfunction in FG and DC, with typical functioning in SV, CPr and MAc. Above average functioning was evident in the maximum scores obtained in DC and the advanced functioning in MAc.

Tactile discrimination minimum scores indicated severe dysfunction in FI, LTS and MFP and a definite dysfunction in GRA. The median score in MFP remained in the dysfunctional range. Above average functioning was noted in FI and advanced functioning in LTS.

Tests of praxis obtained minimum scores indicating various levels of dysfunction, with PrVC, PPr and SPr being the most severely affected, closely followed by OPr and BMC. Median scores for SPr and PrVC indicated dysfunction, while scores for BMC, PPr and OPr were in the typical performance range. Advanced functioning was noted in the maximum score obtained in BMC, and above average functioning evident in SPr and OPr.

Vestibular and proprioceptive functioning indicated difficulties in performance of tests, with KIN and PRN tests obtaining minimum and median scores indicating a level of dysfunction. SWB had a minimum score in the range of severe dysfunction. Advanced functioning was indicated in SWB, with the maximum score obtained being in this range. There was also evidence of above average functioning in KIN, indicated by the maximum score in this test.

Table 4.38 Range of SIPT scores of members of the study population receiving L-asparaginase (n=11)

	minimum	Median	maximum
Form and space perception, visual motor construction & construction			
SV	-3.00	-0.73	0.56
FG	-2.41	-1.25	0.76
DC	-3.00	-1.52	1.93
CPr	-3.00	-0.80	0.76
MAc	-2.77	-0.13	2.58
Tactile Discrimination			
FI	-3.00	-0.53	1.89
LTS	-3.00	-0.66	2.55
MFP	-3.00	-1.76	0.64
GRA	-2.47	-0.82	0.33
Praxis			
BMC	-1.68	-0.22	2.37
SPr	-2.64	-0.72	1.03
PPr	-2.85	-0.40	0.92
OPr	-2.01	-0.35	1.60
PrVC	-3.00	-1.98	0.39
Vestibular and Proprioceptive processing			
KIN	-3.00	-1.86	1.20
SWB	-3.00	0.32	2.65
PRN	-2.35	-1.01	0.77

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= Kinaesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

4.7.7 Methotrexate

Miminum, median and maximum SIPT scores for members of the study population receiving systemic methotrexate are represented in **Table 4.39.**

Tests of Form and space perception, visual motor construction & construction, showed minimum scores in the severely dysfunctional range for all tests except FG, which had a minimum score indicating a definite dysfunction. Median scores indicated dysfunction in FG and DC, with typical functioning in SV, CPr and MAc. Above average functioning was evident in the maximum scores obtained in DC and advanced functioning in MAc.

Tactile discrimination minimum scores indicated severe dysfunction in LTS, MFP and GRA, and a definite dysfunction in FI. The median score in MFP remained in the dysfunctional range. Above average functioning was noted in FI and advanced functioning in LTS.

Tests of praxis obtained minimum scores indicating severe dysfunction in SPr, PPr, OPr and PrVC, with BMC scores indicative of a mild dysfunction. Median scores for all practic tests were in the typical functioning range, with only PrVC being in the severe dysfunctional range. Advanced functioning was noted in the maximum score obtained in BMC, and above average functioning evident in SPr and OPr.

Vestibular and proprioceptive functioning indicated difficulty in performance of tests, with KIN, SWB and PRN tests obtaining minimum scores indicating a severe level of dysfunction. KIN and PRN obtained median scores indicating dysfunction in this group of members of the study population. Above average function was noted in the maximum score obtained in KIN. SWB had a maximum score in the advanced function range.

Table 4.39 Range of SIPT scores of members of the study population receiving Methotrexate (n=14)

	minimum	Median	maximum
Form and space perception, visual motor construction & construction			
SV	-3.00	-0.80	0.56
FG	-2.41	-1.13	0.80
DC	-3.00	-1.59	1.93
CPr	-3.00	-0.77	0.76
MAc	-3.00	-0.41	2.58
Tactile Discrimination			
FI	-2.20	-0.35	1.89
LTS	-3.00	-0.61	2.55
MFP	-3.00	-1.64	0.64
GRA	-3.00	-0.92	0.33
Praxis			
BMC	-1.79	-0.26	2.37
SPr	-3.00	-0.97	1.03
PPr	-3.00	-0.74	0.92
OPr	-2.62	-0.48	1.60
PrVC	-3.00	-3.00	0.39
Vestibular and Proprioceptive processing			
KIN	-3.00	-1.63	1.20
SWB	-3.00	0.00	2.65
PRN	-2.35	-1.06	0.77

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= Kinaesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

4.7.8 Vincristine

Table 4.40 represents the range of scores (minimum, median and maximum) obtained in the SIPT by members of the study population receiving Vincristine.

Tests of Form and space perception, visual motor construction & construction, showed minimum scores in the severely dysfunctional range for all tests. Median scores indicated mild dysfunction in all tests except MAc, which had a score indicating typical function. Above average functioning was evident in the maximum scores obtained in FG, DC and CPr and advanced functioning in MAc.

Tactile discrimination minimum scores indicated severe dysfunction in all tests, while median scores for MFP indicated a definite dysfunction and GRA a mild dysfunction. Above average functioning was noted in FI and advanced functioning in LTS.

Tests of praxis obtained minimum scores indicating severe dysfunction in SPr, PPr, OPr and PrVC, with BMC scores indicative of a mild dysfunction. Median scores for three practic tests were in the typical functioning range, with SPr being in the mild dysfunction range and PrVC being in the severe dysfunction range.
Advanced functioning was noted in the maximum score obtained in BMC, and above average functioning evident in SPr and OPr.

Vestibular and proprioceptive functioning tests scores indicated a severe level of dysfunction performance of tests of KIN and SWB. PRN minimum score indicated a definite dysfunction. KIN and PRN also obtained median scores indicating dysfunction in this group of members of the study population. Above average function was noted in the maximum score obtained in KIN. SWB had a maximum score in the advanced function range.

Table 4.40 Range of SIPT scores of members of the study population receiving Vincristine (n=28)

	minimum	Median	maximum
Form and space perception, visual motor construction & construction			
SV	-3.00	-1.43	0.83
FG	-2.77	-1.29	1.28
DC	-3.00	-1.93	1.93
CPr	-3.00	-1.03	1.34
MAc	-3.00	-0.61	2.75
Tactile Discrimination			
FI	-3.00	-0.79	2.02
LTS	-3.00	-0.75	2.55
MFP	-3.00	-2.49	0.64
GRA	-2.74	-1.17	0.33
Praxis			
BMC	-2.04	-0.42	2.37
SPr	-3.00	-1.12	1.50
PPr	-3.00	-1.11	0.92
OPr	-2.62	-0.56	1.60
PrVC	-3.00	-2.99	0.39
Vestibular and Proprioceptive processing			
KIN	-3.00	-1.49	1.32
SWB	-3.00	-0.25	2.65
PRN	-2.35	-1.06	0.77

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= Kinaesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

4.7.9 Prednisone

Table 4.40 visually represents minimum, median and maximum SIPT scores obtained in all subtests for the 17 members of the study population receiving prednisone.

Tests of Form and space perception, visual motor construction & construction, showed minimum scores in the severely dysfunctional range for all tests except FG, which had a minimum score indicating a definite dysfunction. Median scores indicated mild dysfunction in FG and CPr, with scores obtained in DC and MAc indicating severe dysfunction. Above average functioning was evident in the maximum scores obtained in DC and advanced functioning in MAc.

Tactile discrimination minimum scores indicated severe dysfunction in all tests. The median score in MFP and GRA remained in the severe and mild dysfunction range respectively. Above average functioning was noted in FI and advanced functioning in LTS.

Tests of praxis obtained minimum scores indicating severe dysfunction in SPr, PPr, OPr and PrVC, with BMC scores indicative of a mild dysfunction. Median scores for SPr and PPr indicated a mild dysfunction, with only PrVC being in the severe dysfunction range. Advanced functioning was noted in the maximum score obtained in BMC, with above average functioning evident in SPr and OPr.

Vestibular and proprioceptive functioning indicated difficulty in performance of tests. KIN and SWB tests obtained minimum scores indicating a severe level of dysfunction and the PRN score indicated definite dysfunction. KIN and PRN obtained median scores indicating dysfunction in this group of members of the study population. Above average function was noted in the maximum score obtained in KIN. SWB had a maximum score in the advanced function range.

Table 4.41 Range of SIPT scores of members of the study population receiving Prednisone (n=17)

	minimum	Median	maximum
Form and space perception, visual motor construction & construction			
SV	-3.00	-0.91	0.56
FG	-2.41	-1.25	0.76
DC	-3.00	-2.89	1.93
CPr	-3.00	-1.01	0.76
MAc	-3.00	-2.02	2.23
Tactile Discrimination			
FI	-3.00	-0.75	1.89
LTS	-3.00	-0.65	2.55
MFP	-3.00	-2.51	1.05
GRA	-3.00	-1.73	0.33
Praxis			
BMC	-1.85	-0.86	2.37
SPr	-3.00	-1.22	1.03
PPr	-3.00	-1.29	0.92
OPr	-2.62	-0.61	1.51
PrVC	-3.00	-3.00	-0.84
Vestibular and Proprioceptive processing			
KIN	-3.00	-1.73	1.20
SWB	-3.00	-0.71	2.65
PRN	-2.35	-1.14	0.77

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= Kinaesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

4.7.10 Doxorubicin

Table 4.42 represents score ranges for members of the study population receiving Doxorubicin**.**

Tests of Form and space perception, visual motor construction & construction, showed minimum scores in the severely dysfunctional range for all tests. Median scores indicated various levels of dysfunction in all tests too. Above average functioning was evident in the maximum scores obtained in FG, DC and CPr and advanced functioning evident in the score obtained in MAc.

Tactile discrimination minimum scores indicated severe dysfunction in all tests. The median scores in LTS and GRA remained in the dysfunctional range. Above average functioning was noted in FI and advanced functioning in LTS.

Tests of praxis obtained minimum scores indicating severe dysfunction in SPr, PPr, OPr and PrVC, with BMC scores indicative of a mild dysfunction. Median scores for SPr and PPr were in the mild dysfunction range, with PrVC remaining in the severe dysfunction range. Advanced functioning was noted in the maximum score obtained in BMC, and above average functioning was evident in SPr and OPr.

Vestibular and proprioceptive functioning indicated difficulty in performance of tests, with KIN and SWB obtaining minimum scores which indicated a severe level of dysfunction and the PRN test score indicated a definite dysfunction. KIN and PRN obtained median scores indicating dysfunction. Above average function was noted in the maximum score obtained in KIN and SWB.

Table 4.42 Range of SIPT scores of members of the study population receiving Doxorubicin (n=25)

	minimum	Median	maximum
Form and space perception, visual motor construction & construction			
SV	-3.00	-1.51	0.83
FG	-2.77	-1.33	1.28
DC	-3.00	-2.19	1.19
CPr	-3.00	-1.01	1.34
MAc	-3.00	-1.01	2.58
Tactile Discrimination			
FI	-3.00	-0.93	1.53
LTS	-3.00	-0.75	2.14
MFP	-3.00	-1.76	0.64
GRA	-3.00	-1.16	0.19
Praxis			
BMC	-2.04	-0.63	2.23
SPr	-3.00	-1.03	1.50
PPr	-3.00	-1.29	0.92
OPr	-2.62	-0.68	1.60
PrVC	-3.00	-3.00	0.39
Vestibular and Proprioceptive processing			
KIN	-3.00	-1.49	1.32
SWB	-3.00	-0.71	1.29
PRN	-2.35	-1.04	0.36

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= Kinaesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

4.7.11 Dexamethasone/ Decadron

Table 4.43 visually represents the range of SIPT scores obtained for members of the study population receiving Dexamethasone.

Tests of Form and space perception, visual motor construction & construction, showed minimum scores in the severely dysfunctional range for all tests except FG, which had a minimum score indicating a definite dysfunction. Median scores indicated dysfunction in FG and DC, with typical functioning in SV, CPr and MAc. Advanced functioning was evident in the maximum score obtained in MAc.

Tactile discrimination minimum scores indicated severe dysfunction in LTS and MFP, while GRA and FI indicated scores in the definite dysfunction range. The median score in MFP was in the definite dysfunction range and the GRA score indicated a mild dysfunction. Above average functioning was noted in FI and advanced functioning in LTS.

Tests of praxis obtained minimum scores indicating severe dysfunction in SPr, PPr and PrVC, with the OPr score indicating definite dysfunction and BMC score indicating mild dysfunction. Median scores for all practic tests were in the typical functioning range, only PrVC remained in the severe dysfunction range. Advanced functioning was noted in the maximum score obtained in BMC, and above average functioning evident in SPr and OPr.

Tests of Vestibular and proprioceptive functioning indicated severe dysfunction in KIN, and definite dysfunction in SWB and PRN. Median scores for KIN and PRN remained indicative of a dysfunction, although mild. The above average score for PRN indicated a dysfunction in processing vestibular information.

Table 4.43 Range of SIPT scores of members of the study population receiving Dexamethasone/ Decadron (n=12)

	minimum	Median	maximum
Form and space perception, visual motor construction & construction			
SV	-3.00	-0.89	-0.10
FG	-2.41	-1.25	0.76
DC	-3.00	-2.04	-0.91
CPr	-3.00	-0.91	-0.35
MAc	-2.81	-0.14	2.58
Tactile Discrimination			
FI	-2.20	-0.71	1.49
LTS	-3.00	-0.63	2.55
MFP	-3.00	-2.11	0.64
GRA	-2.40	-1.16	0.33
Praxis			
BMC	-1.68	-0.26	2.37
SPr	-2.85	-0.97	1.03
PPr	-2.91	-0.74	0.92
OPr	-2.01	-0.29	1.60
PrVC	-3.00	-3.00	0.39
Vestibular and Proprioceptive processing			
KIN	-3.00	-1.84	0.96
SWB	-2.04	0.17	2.65
PRN	-2.35	-1.11	1.44

(SV= Space Visualisation, FG= Figure ground, DC= Design Copying, CPr= Constructional Praxis, MAc = Motor Accuracy, FI = Finger Identification, LTS= Localisation of Tactile Stimuli, MFP= Manual Form Perception, GRA= graphesthesia, BMC= Bilateral Motor Coordination, PPr = Postural Praxis, SPr= Sequencing Praxis, OPr = Oral Praxis, PrVC= Praxis on Verbal Command, KIN= Kinaesthesia, SWB= Standing and Walking Balance, PRN= Postrotary Nystagmus)

4.8 SENSORY PROFILE

The frequency of occurrence of scores indicating typical performance, probable difference and definite difference in the sensory profile caregiver questionnaire which was administered in 14 members of the childhood cancer sample group is represented in **Table 4.44.**

Analysis of the factor summary, indicated 57% of the group had differences compared to the normal population in sensory seeking behaviour, 50% had differences in emotional reactivity, 71% had differences in low endurance and tone, 78% had differences in oral sensory sensitivity, 35% had differences in inattention or distractibility, 57% had differences in poor registration, 71 % had differences in sensory sensitivities, 35% had differences in sedentary activities and 35% had differences in fine motor or perceptual skills. Of these definite differences were found in the following percentages of the sample group (n=14): sensory seeking behaviour (50%), emotional reactivity (29%), low endurance and tone (57%), oral sensory sensitivity (64%), inattention or distractibility (21%), poor registration (43%), sensory sensitivities (50%), sedentary activities (21%) and fine motor or perceptual skills (14%).

Sensory processing scores in each sense revealed differences in perception and processing of auditory (35%), visual (21%), vestibular (79%), touch (65%), multisensory (35%) and oral sensory (78%) stimuli, with definite differences noted in auditory (21%), vestibular (34%), touch (36%), multisensory (21%) and oral sensory (64%) stimuli.

Members of the study population participating in this study had modulation difficulties with varying differences in ability between the sample group and the normal population seen in modulation with regards to endurance or tone (71%), body position and movement (64%), modulation of movement affecting activity level (64%), modulation effect on emotional responses (57%) and modulation of visual input affecting emotion and activity (72%). Definite differences were noted in the following percentages: modulation with regards to endurance or tone (64%), modulation affecting body position and movement (64%), modulation of movement affecting activity level (21%), modulation effect on emotional responses (43%) and modulation of visual input affecting emotion and activity (36%).

Examination of scores of the members of the study population in behavioural and emotional responses indicated differences in emotional and social responses (43%), behavioural outcomes of sensory processing (64%), and thresholds for response (57%); with definite differences in 29%, 21% and 43 % respectively.

Table 4.44 Sensory Profile findings from Caregiver Questionnaires completed (n=14)

Factor summary			
	typical performance	probable difference	definite difference
Sensory seeking	6 (43%)	1 (7%)	7 (50%)
Emotionally reactive	7 (50%)	3(21%)	4 (29%)
Low endurance/tone	4 (29%)	2(14%)	8 (57%)
Oral sensory sensitivity	3 (21%)	2(14%)	9 (64%)
Inattention/ distractibility	9 (64%)	2(14%)	3 (21%)
Poor registration	6 (43%)	2(14%)	6 (43%)
Sensory sensitivity	4 (29%)	3(21%)	7 (50%)
Sedentary	9 (64%)	2(14%)	3 (21%)
Fine motor/ perceptual	9 (64%)	3(21%)	2 (14%)
Sensory processing			
	typical performance	probable difference	definite difference
Auditory	9 (64%)	2 (14%)	3(21%)
Visual	11 (79%)	3 (21%)	0 (0%)
Vestibular	3 (21%)	5 (36%)	6 (43%)
Touch	5 (36%)	4 (29%)	5 (36%)
Multisensory	9 (64%)	2 (14%)	3 (21%)
Oral sensory	3 (21%)	2 (14%)	9 (64%)
Modulation			
	typical performance	probable difference	definite difference
Endurance/tone	4 (29%)	1 (7%)	9 (64%)
Body position & movement	5 (36%)	0 (0%)	9 (64%)
Movement affecting activity level	5 (36%)	6 (43%)	3 (21%)
Affecting emotional responses	6 (43%)	2 (14%)	6 (43%)
Visual input affecting emotion and activity	4 (29%)	5 (36%)	5 (36%)
Behavioural and emotional response			
	typical performance	probable difference	definite difference
Emotional/ social response	8 (57%)	2 (14%)	4 (29%)
Behavioural outcomes	5 (36%)	6 (43%)	3 (21%)
Thresholds for response	6 (43%)	2 (14%)	6 (43%)

4.9 CONCLUSION

Results were reported and visually represented for demographics and characteristics of the sample group. The prevalence of Sensory Integrative disorders was examined by reporting the SIPT scores in domains of function, comparison to score patterns of diagnostic groups and identified partial patterns of dysfunction, upper limb function, behavioural responses to testing on the SIPT and clinical observations of prone extension, supine flexion and ocular pursuits. Chemotherapy methods of administration as well as the SIPT scores obtained in domains of function for members of the study population receiving chemotherapy previously documented to have late neurocognitive and neurobehavioral effects was reported. Finally sensory profile scores in a subset of the population were reported.

The results showed a group of members of the study population to have sensory integrative disorders best explained by visuo- and somatodyspraxia or a generalised sensory integrative disorder.

There was evidence of dysfunction in domains of form and space perception, visual motor construction and construction; tactile discrimination, praxis and vestibular and proprioceptive processing in members of the study population exposed to the chemotherapy agents examined.

Sensory profile scores indicated differences in sensory processing abilities, as reported by caregivers, in a noteworthy portion of the population.

The sample group, although small, is representative of the childhood cancer population in State hospitals in Gauteng and the Free State, as it consisted of a range of childhood solid tumours, leukaemia and lymphoma, typically seen in oncology units in South Africa.

CHAPTER 5

-DISCUSSION-

5.1 INTRODUCTION

The aim of the study was to investigate the prevalence of Sensory Integrative disorders among the childhood cancer population. Results were tabulated and represented in figures in chapter 4. The important findings will be discussed to formulate the findings of this study.

5.2 SIPT SCORES, AREAS OF FUNCTIONING AND CHEMOTHERAPY

Members of the study population with cancer are not typically developing. The diagnosis of and treatment for childhood cancer is not a typical event experienced in a normal childhood, their medical condition may make them different from most typically developing members of the study population, members of the study population with learning disabilities or children with sensory integrative disorders, and thus the scores should be interpreted with caution and may be problematic (Ayres, 2004, p148).

SIPT scores are provided as SD or z-scores and indicate the degree of deviation from the mean of the normal population (mean = 0.00, SD=1). These scores are calculated by the SIPT PC disk after the child's scores are recorded in the answer booklet and entered on a computer scoring program following the onscreen prompts. This eliminates the possibility of incorrectly computing SD or z-scores used in reporting results. Scores can be analysed globally to determine if the child scores similarly to others in a predetermined diagnostic groups (discussed in **Section 2.2.3),** individually or in meaningful partial patterns. Partial patterns of sensory integrative dysfunctions, which have been found to be significant on factor analysis, may also become evident when SIPT scores are analysed more closely and specific areas are attended to.

The SIPT subtests assess sensory integrative skills and functioning in four major areas: form and space perception with visual motor construction and construction (SV, FG, DC, CPr, MAc), tactile discrimination (FI, LTS, MFP, GRA), praxis (BMC, SPr, PPr, OPr, PrVC), and vestibular and proprioceptive processing (KIN, SWB, PRN) (Bundy *et al*,2002, p171).

5.2.1 Form and Space Perception, Visuomotor Construction and Construction.

Form and space perception develops as sensorimotor information is integrated with visual information and the internal map of out body position and movement merges with an external map of position and physical characteristics of objects and the environment (Ayers, 2005, p116, 119). Adequate form and space perception is vital to enable appropriate environmental interaction. Children with poor form and space perception will have difficulties in school based activities like colouring in within the outlines of a picture, reproduce print, and following the line of print while reading or transcribing what a teacher had written on the board. On a play level, he may have difficulty with ball sports as this requires him to track the path of a moving object through space and coordinate his body movements to act appropriately on this.

Visual perception occurs on two levels of brain activity: a brainstem level, where vestibular, proprioceptive and visual information are amalgamated into a single process, and a cerebral hemispheric level, where more specialised interpretation occurs (Ayers, 2005, p116, 119). The information processed on a brain stem level provides an internal map of the body and its position in space. The interpretation that takes place on a cerebral level enables us to see an object in detail and relative to its background; skills used in the SV and specifically FG tests. This processing enables our eyes to move whilst looking at something, a skill essential for keeping the red pen line on the pre-printed thick black line when completing the MAc. Poor visual discrimination and poor scores on visual perceptual tests are indicative of poor processing and inadequate integration between the vestibular, proprioceptive and the visual area of the cerebral cortex (Ayers, 2005, p116, 119).

In the study population, 67% of members of the study population had difficulty with SV. This is indicative of a difficulty merging information received and processed by the visual system, with an internal map of how an objects orientation can be changed in space to alter the visual image it presents. The end product of this test is being able to mentally manipulate the orientation of an egg or diamond shaped block to fit it into a shaped hole. This same skill however would be used in functional activities such as packing items into a storage container, reading text that is misaligned and orientating oneself to make sense of what is seen in the environment when one’s head is out of midline. These results show a marked prevalence of difficulty in SV in the childhood cancer population tested, and functional difficulties relying on this skill can be expected in 67% of the members of the study population **(cf Table 4.10).**

Accurate FG perception is a result of cerebral interpretation of visual input, providing context and information about an object and its environment (Bodison & Mailloux, 2006, CE-4). There was a 64% prevalence of difficulties or disorders in FG perception in this population. The FG score is helpful in identifying a visual perceptual deficit. This test is however vulnerable to guessing and impulsive choices, and the prevalence of dysfunction reported may not be skewed by this (Ayres, 2004, p135). In validity studies of the SIPT, FG was found to be sensitive to high level central nervous system integrity and these scores should be examined in light of scores on PRN and PrVC (Ayres, 2004, p135). Poor FG scores caused by cerebral inefficiency will be associated with high PRN scores and low PrVC scores **(cf Section 5.3.4).**

Fine motor control is needed in addition to form and space perception and vestibular ocular integration to perform the MAc test. In right handed individuals, the right hand usually has superior functioning in fine motor skills when compared to the left (Ayres, 2005, p59). In the members of the study population tested (n=37, 100%), used their right hand first. The left accuracy scores were higher than right, possibly due to inefficient sensory processing of visual and proprioceptive information, or inefficient bilateral integration and specialisation, with similar skills developing for each hand, neither of which are particularly well developed (Ayres, 2005, p75). MAc performance requires vestibular and bilateral function to coordinate the simultaneous movement of the eyes, head and hand, and link these with postural adjustments and midline crossing (Mailloux *et al*, 2011, p148).

Design Copying errors are atypical approaches to reproducing the stimulus figure. DC is the strongest indicator of visuopraxis in the SIPT; low scores on this test indicate difficulty with visuopraxis (Ayres 2004, p45).

DC errors or atypical approaches are defined as follows (Ayres 2004, p45):

Additions are extra lines or "grossly inappropriate, nonnormal, deliberate, and illogical additions to a figure" (Ayres, 2004, p45). They may be added for different reasons, including a random, disorganised attempt at replicating the figure, a perseveration or an attempt at embellishment. Excessive redrawing of a line back on itself is considered an addition, as this shows perseverative behaviour.

Boundary refers to the printed block in which the child has to replicate the drawing on the test booklet. This is scored as a "should not have" parameter if the child uses this printed line as part of the drawing; his drawing touches the boundary, or if part of the figure is drawn outside the boundary.

Jogs or Ears are "a definite identifiable quality of irregularity at a corner or in a line". These are purposefully produced due to confusion if the child in planning g and executing the direction of drawing, when he is trying to make a corner with one continuous line.

Reversal occurs when details on one side of the stimulus figure are drawn on the opposite side in the child's reproduction, with the child's drawing being a mirror image of the stimulus.

Right to Left is when the child's drawing is started on the right, and his lines continued to the left.

Inversion is the reproduction of a figure which is upside down.

Segmentation is when a drawing is not done in a logical sequence, indicating that the child visually perceives the stimulus figure in a way which is different to his peers. A drawing may be perceived as separate parts joined together instead of as a unit, and the child's approach to copying it will reflect this perception. It gives an indication of the child's spatial awareness.

Many members of the study population approached this task in a typical manner, with the greatest percentage of scores being in the ranges of typical and above average functioning. However, scores indicative of a level of dysfunction were present in left to right, reversals, inversions and segmentations in a portion of the study population **(cf Table 4.11, Section 4.3.1.1)**, indicating leftward orientation, poor visual spatial management and poor right hand preference (Ayres, 2004, p 137). Children, who have difficulties in DC, will have difficulties with other functional and academic tasks requiring two-dimensional space management, including drawing and handwriting (Ayres, 2004, p 137; Ayres, 2005, p53, 121). Many members of the study population (43%) approached the drawings in a segmental way, indicating that their visual perception of the picture was segmented instead of a complete unit.

Performance in the test of Constructional Praxis (CPr), gives an indication of the child's ability to manipulate objects in three-dimensional space, and his perception of and relation to his three-dimensional world. Errors in block placement are recorded in the child's attempt to replicate the three dimensional model in part 2. This part is only administered to children over the age of four years. If the block is placed in a position where it is incorrect on more than one parameter, it is scored on its most erroneous parameter, with errors increasing in severity from parameters 1 to 7 (Ayres, 2004, p70). Errors are determined according to the following parameters:

1. **Displacement of 1 through 2½ cm.** The block is placed in the correct location and with the correct orientation, but displaced 1 to 2½ cm in relation to the model.
2. **Displacement more than 2½ cm.** The block is placed in the correct location and with the correct orientation, but displaced 1 to 2½ cm in relation to the model.

3. **Rotation more than 15 degrees.** The block is rotated around a vertical axis by more than 15□, but not sufficiently so to have it considered a right to left or front to back (parameter 4) error.
4. **Upside down, right for left, front for back, or end for end.** Rotation of the block around a vertical axis so that it is positioned upside down, reversed or vertical instead of horizontal, despite resting on the correct blocks and in the correct position.
5. **Placement incorrect but logical.** A placement of a block which makes a meaningful and logical contribution to the model, but is incorrect in its choice, such as substitution with a block of a similar shape.
6. **Gross Mislocation.** Placement of a block in the structure without a logical resemblance to the block's position in the model. Blocks randomly placed in the model or pushed up against the model.
7. **Omission.** Any blocks not included in the model when the child has indicated that they have completed the task.

   Ok. Placement of the block in the correct position with the correct orientation, with an error not scored on any previous parameter, if slight error is present

Most members of the study population performed typically, or even above average in this investigation into CPr functioning, indicating that their three-dimensional space management and ability to manipulate objects in their environment is intact **(cf Table 4.12, Section 4.3.1.2)**. There however, were some members of the study population, who performed very poorly, with 28% of members of the study population making the most serious errors of gross mislocation and omissions, because the task was too challenging for them and their three dimensional space management was not adequate to enable them to place the blocks accurately (Ayres, 2004, p137). These members of the study population will have difficulty on a functional level in orientating themselves in space, finding their way around, participating in team sport where they need to get into a position to receive a ball and similar activities (Ayres, 2005, p116).

Section 2.5 details previous literature on the findings of studies on neurocognitive and neurobehavioral side effects of childhood cancer treatment. Prednisone, Cyclophosphamide, Vincristine, L-asparaginase and intravenous Methotrexate, Hydrocortisone and Cytosine Arabinoside, has been shown to cause neurocognitive side effects, including visual constructional abilities (Moore, 2005, p p51-63, Espy *et al*, 2001, p1). Visual organisation, a skill that is used in tests in the domain of form and space perception, visual motor construction and construction, has been specifically found to be affected by these chemotherapeutic agents (Keene, 2002, p299, 300). Efficient eye hand coordination is necessary for effective participation in tests of visual motor construction and construction, and findings of poor eye hand coordination have been reported by the Texas Children's Cancer Centre. Other studies have documented difficulties in visuographic abilities, visual motor functioning and fine motor skills, all necessary for performance in DC and MAc (McDougal, 1997; Salmi, Toivo T, Äärimaa, Tuula, 2003, p28-31).

Tables 4.33 to 4.43 visually represent the minimum, median and maximum SIPT scores of members of the study population receiving each type of chemotherapy documented to have a neurocognitive or neurobehavioral side effect **(cf Section 2.5).**

Minimum scores in tests of form and space perception, visual motor construction and construction were in the dysfunctional range subjects receiving any of the drugs administered. Median scores for all these tests were indicative of a level of dysfunction (mild to definite) in members of the study population receiving Cytosar and Doxorubicin. Median scores in tests of Tests of Visuographic Skills (DC), were in dysfunctional ranges in members of the study population receiving Cyclophosphamide **(cf Table 4.33)**, Cytarabine **(cf Table 4.34)**, intrathecal Hydrocortisone, Methotrexate and Cytosar **(cf Tables4.35, 4.36, 4.37),** L-Asparaginase **(cf Table 4.38)**, systemic Methotrexate **(cf Table 4.39)**, Vincristine **(cf Table 4.40)**, Prednisone **(cf Table 4.41)** Doxorubicin **(cf Table 4.42)** and Dexamethasone **(cf Table 4.43)**. These are findings which are confirmed by literature and previous studies **(cf Section 2.5).** Also in keeping with previous findings, visual motor functioning and fine motor skills also obtained median scores in dysfunctional ranges in members of the study population receiving Cyclophosphamide **(cf Table 4.33)**, intrathecal Cytosar **(cf Table 4.37),** Prednisone **(cf Table 4.41) and** Doxorubicin **(cf Table 4.42).**

These results indicate difficulties in activities requiring form and space perception, visual motor construction, and construction in accordance with previous studies. These members of the study population will experience difficulties on a functional level at school, in writing and drawing (Ayres, 2004, p137).

There were members of the study population who obtained scores indicative of advanced functioning, specifically in MAc. The documented long term effects of treatment did not seem to affect the visuographic or visual motor functioning of all members of the study population receiving the drug. MAc performance is reflective of vestibular and bilateral functions needed to coordinate movements of the child's eyes, head and hands, and make the postural adjustments and cross the body midline during performance (Mailloux *et al*, 2011, p148). The advanced functioning in MAc could be indicative of the level of sensitivity to and integration of information from the vestibular and proprioceptive sense.

5.2.2 Tactile Discrimination

Tactile discrimination difficulties are often experienced by members of the study population with some level of dyspraxia. They may have a decreased perception of touch, but more often their sensitivity is heightened, and they may be acutely aware of the location and presence of tactile input, and may respond in an amplified manner, or negatively to this. Some members of the study population may appear unaware that they have been touched, or may be aware of the touch, but unable to interpret any information regarding the qualities of the object that touched them, leading to severe functional implications in daily life (Ayres, 2005, p91).

In the SIPT, the child is required to focus his attention on the part of his hand or forearm that is being touched (FI, GRA, LTS) or on the object that is placed in his hand (MFP). Doing this makes him aware of this stimulus, and allows the information from the stimulus to travel up to and be processed on a higher cerebral level, the sensory cortex and conscious awareness (Ayres, 2005, p92), and then allows the child to react to the demand set by the environment.

The prevalence of scores in the severely dysfunctional range in MFP, indicate that 44% of the members of the study population had severe difficulty discriminating what it was they were feeling in their hands. MFP is an important skill, as it is indicative of stereognostic ability, allowing the child to identify objects by their tactile qualities as opposed to their visual qualities. On a functional level, these members of the study population would have difficulty with tasks removing change from a pocket or the bottom of a bag to purchase something at the school tuckshop, and find an item of stationery in their school bag or chair bag. MFP is the first of the tactile tests administered in the SIPT, so the cumulative effect of loading of sensory information and a resultant hypersensitive reaction due to poor modulation is not a likely explanation for the poor scores achieved here. The poor scores can better be explained by the presumption that the processing of this information on a cortical level is not sufficient and the incoming information from the tactile receptors is deficient or vague (Ayres, 2005, p94). The left hand in a right handed person is usually more advanced in tactile discrimination and interpreting what is in the hand, whilst the right hand is more skilled in fine motor tasks (Ayres, 2005, p59), This holds true for the sample of the childhood cancer population tested, none of which were left dominant. The accuracy scores for the left hand on MFP part 1 and 2 are generally higher than those for the right hand **(cf Table 4.26).**

FI and LTS involve the accurate, specific interpretation of the location of tactile stimuli to the hand (FI) and hand and forearm (LTS). LTS scores were almost evenly split between dysfunction and typical functioning **(cf Table 4.14).** Advanced functioning in LTS indicates a very precise perception of the location of tactile input to the hand and forearm. Scores in the higher ranges in tactile processing (typical performance and better) may be indicative of a tactile defensiveness or hypersensitivity, as tactually defensive children may not have low tactile scores (Ayres, 2004, p136).

There were members of the study population in this study sample who refused participation in this test, and responded with refusal, withdrawal, heightened anxiety and other signs indicative of a stress reaction (fright, flight or fight response) **(cf Table 4.27).** This response would not occur if the child was feeling confident in his abilities, and if the idea of being touched, and the anticipation of this touch was not frightening to him (Ayres, 2005, p107). Hypersensitivity may result in elevated scores. Children with cancer often receive their chemotherapy through peripheral intravenous lines in the hand or forearm, areas that are touched in the LTS test **(cf Figure 4.4).** The anticipation of this touch as painful, and the possible heightened pain reaction due to multiple venipuncture procedures may account for the heightened scores, especially in those in the advanced function range. The accuracy scores for the left hand were not consistently higher in FI or LTS, as expected in right handed children (Ayres, 2005, p59) possibly due to the influence of peripheral lines administration of chemotherapy interfering with the development of tactile perception by a foreign body (drip needle) interfering with the reception of tactile information and subsequent conduction of this information to the sensory cortex.

GRA assesses the child's ability to receive and interpret complex tactile information and generate a motor response imitating the production of this input. More members of the study population received scores indicative of dysfunction, than typical functioning. The maximum score for the left hand was higher than the right hand, indicating that in members of the study population where this process and skill is intact, functioning is representative of normally developing children. However, where difficulty is experienced in processing this information and generating a motor act from it, the left and right accuracy scores are comparably poor, possibly due to peripheral administration of chemotherapy interfering with the development of complex tactile perception in the hand.

In investigation of the minimum, median and maximum scores obtained in SIPT tests of tactile discrimination for each chemotherapy agent known to have neurocognitive or neurobehavioural late effects **(cf Section 2.5),** it was noted that tactile processing minimum scores for members of the study population receiving any of the eleven investigated agents were in ranges of severe or definite dysfunction **(cf Tables 4.33 to 4.43).** Children with scores in tactile processing in a range of severe or definite dysfunction do not understand the information received by tactile and proprioceptive receptors in their hands and forearms, cannot make sense of this and are unable to use any information regarding the form, texture, contour or location of a stimulus (Ayres, 2005, p94). MFP and GRA obtained median scores in dysfunctional ranges in members of the study population being treated with Cyclophosphamide **(cf Table 4.33),** Cytarabine **(cf Table 4.34),** intrathecal Hydrocortisone, Methotrexate and Cytosar **(cf Table 4.35, Table 4.36, Table 4.37),** Vincristine **(cf Table 4.40),** Prednisone **(cf Table 4.41),** Doxorubicin **(cf Table 4.42)** and Dexamethasone **(cf Table 4.43).** Cytarabine and Vincristine have been documented to cause peripheral neuropathy **(cf Section 2.5)**, which would have a negative effect on tactile discrimination, as the messages from tactile and proprioceptive receptors are not being adequately relayed to higher cortical areas for interpretation (Bundy *et al*, 2002, p47, 48).

LTS and FI consistently obtained scores in and above average or advanced functioning range in members of the study population receiving any of the 11 drugs investigated **(cf Tables 4.33 to 4.43).** These high scores indicate hypersensitivity to the tactile stimuli inherent in these tests. In a study designed to clarify patterns of sensory integration dysfunction, Mailloux *et al* (2011) hypothesised that " tactile perception tests would be associated with each other or with other sensory perception tests" and "sensory overresponsiveness and attention would be associated" (Mailloux *et al*, 2011, p145). This sensory overresponsiveness, or what Ayres referred to as tactile defensiveness (Ayres IN Mailloux *et al*, 2011, p144), may have an effect on the child's arousal level and ability to pay attention to the tasks at hand.

5.2.3 Praxis

BMC, SPR, PPr and OPr had a high prevalence of scores in the typical range and in the mild dysfunction range.
BMC has a somatic foundation, and is influenced by the presence of somatodyspraxia **(cf Table 4.18** and **Section 4.3.2.2)**, and a Vestibular and Proprioceptive Bilateral Integration and Sequencing factor (Mailloux *et al*, 2011, p148). The scores in the mildly dysfunctional range and the one definite dysfunction score could be accounted for by the members of the study population having difficulty with the somatic component of the test, not having a clear idea of the movement of their upper limbs or feet in space and how to coordinate their movement to reproduce the pattern and rhythm demonstrated by the examiner (Ayres, 2004, p139).

SPr scores were evenly distributed between scores in the typical or above average ranges and the dysfunctional range, however 8 (20%) of members of the study population tested with a severe dysfunction. In the greater picture of sensory integrative disorders, SPr is indicative of the presence of somatodyspraxia **(cf Table 4.18** and **Section 4.3.2.2)** and possibly a bilateral integration and sequencing disorder **(cf Table 4.16** and **Section 4.3.2.1)**. It is not a test that should be interpreted individually, and low scores only have value in a cluster with low scores in OPr, BMC and GRA or other praxis and somatosensory tests (Ayres, 2004, p138). SPr is demonstrated by the examiner, and relies on a degree of visual interpretation and visual memory in its performance (Bundy *et al*, 2002, p455). This could contribute toward the scores in the typical range, as practic tests where there was a demonstration (SPR, PPr, OPr), tapping into visual processing skills, had better performance than PrVC, where the instruction was purely verbal, and auditory interpretation and memory were required to a much greater degree.

PPr had a slightly increased prevalence of scores in the dysfunctional range, indicating a difficulty with practic skills involving, ideation, visual direction and motor performance of a task. This test is strongly linked to the presence of a somatodyspraxia, with a low score here clustering with low scores in OPr, SPr and CPr, and somatosensory tests (Ayres, 2004, p138). This test relies on visual interpretation and memory of the demonstrated item, and strong reliance on the visual system and efficient processing of this information may contribute to scores in the typical and above average range (Bundy *et al*, 2002, p455).

OPr had a high prevalence of scores in the typically developing range, This test is closely related to the perception of tactile sensations throughout the body (Ayres, 2004, p138). There was an increased prevalence of dysfunctional scores in oral processing on the sensory profile **(cf Table 4.44** and **Section 4.8)**. Although the sensory profile was only completed on a subset of the sample group, the increased prevalence if scores in the probable difference (14%) and definite difference (64%) range may be influenced by the same factors resulting in higher praxis scores here, indicating that the members of the study population may be particularly aware of and sensitive tactile and proprioceptive input in the oral area, in and around their mouth. The functional integration of the two sides of the body of these members of the study population as represented in the OPr scores seems to be largely intact, possibly due to adequate visual memory and interpretation of visual information (Bundy *et al*, 2002, p455).

PrVC is greatly affected in this population, with an 87% prevalence of dysfunction, 69% of this being severe. The 3 (8%) members of the study population who cried during the administration of the SIPT **(cf Table 4.27),** did so in this test, as the demands were too overwhelming for them and they were unable to perform the task. The members of the study population had severe difficulty interpreting verbal directions and translating these into motor acts, without any visual cues to guide them. There seems to be a deficit in linguistic processing in many of these members of the study population and this needs to be investigated. In the members of the study population who had a co-occurring deficit in PPr, a postural component to the practic difficulty is strongly suspected, and these are the members of the study population in which a somatodyspraxia seems to be present. Many of the members of the study population were not English or Afrikaans speaking, and a translator was used in the administration of the SIPT. According to the translators at each institution, there are not always words in African dialects which directly translate to the English terms, or concepts such as “back of your hands” and “back of your feet” are foreign to the members of the study population. These verbal reports need to be investigated further and clarified to determine its validity. PrVC scores in this population should be interpreted with caution, although the previous point, of a possible linguistic dysfunction stands.

Minimum scores for SIPT tests or praxis were indicative of dysfunction for members of the study population receiving any of the 11 chemotherapy drugs administered. Maximum scores in above average or advanced function ranges were achieved on tests of OPr, BMC and SPr **(cf Tables 4.33 to 4.43).**

5.2.4 Vestibular and Proprioceptive Processing

The vestibular system acts as an organiser to all other sensory sytems, and dysfunction here has far reaching consequences, with many sensoriomotor patterns beign disorganised (Ayres, 2005, p71,75).

There was a greater prevalence of dysfunctional scores in PRN **(cf Table 4.15)**, indicating a low responsivity of the central nervous system to vestibular input from semicircular canals (Ayres, 2004, p136). These members of the study population may have difficulty coordinating the movements of their eyes to follow a visual target, and this may be contributing to the poor and slightly deficient ocular pursuits noted in clinical observations **(cf Table 4.28)**(Ayres, 2005, p63). Muscle tone is greatly influenced by accurate processing of vestibular information, specifically in anti-gravity postures (from the utricle and saccule). The inefficient processing of vestibular information resulting in low PRN scores in this population may account for the difficulty these members of the study population experience in maintaining the prone extension and supine flexion postures **(cf Table 4.28).** It may also partly account for behaviour seen in testing **(cf Table 4.27),** specifically members of the study population wriggling in their chair (69%) to maintain an upright position at the table (seeking vestibular input to influence muscle tone to maintain an upright posture). Other members of the study population, who lay on their arms (10%), may have done so due to inefffficient processing of vestibular infomation, and thus inefficient relaying of messages to postural muscles to contract to hold this position (Ayres, 2005, p65). There has been much criticism of the PRN test, and many external factors can influence it. The criticism includes the fact that the test is administered in thel ight, thus stimulating the vestibulo-ocular reflex and the opto-kinetic reflex. PRN scores can be depressed by visual fixation, level of alertness and change in head tilt after rotation (Bundy *et al*, 2002, p179). PRN scores in the dysfunctional range need to be compared with scores on tests of postural control (SWB, PPr) to confirm a dysfunction.

The scores obtained in SWB **(cf Table 4.15),** were more prevalent in the typical and above average range, indicating that the processing of vestibular information and the function carried out by the brainstem, influencing balance is adequate (Ayres, 2005, p65). There are however, still a noteworthy number of members of the study population experiencing some level of dysfunction in SWB, due to inefficient processing of vestibular information and subsequent inefficient postural adjustments and balance reactions. Inefficient processing of vestibular information and the resultant deficit in postural adjustments necessary to maintain the relationship betwen the childs body and earth, and his sense of security in environmental space, can be a frightening experience and result in behaviour indicating emotional distress. If the primary relationship between the child's body and the earth is not stable, other relationships will fail to develop optimallly (Ayres, 2005, p70).

The scores reflecting the level of function in KIN were predominantly in the dysfunctional range **(cf Table 4.15)**, with many members of the study population showing a severe dysfunction. This indicated that the information being received by muscle and joint receptors is not being processed efficiently and the child does not have an accurate idea of where his body is in space and the position of his limbs without using visual input. The information received and the interpretation process is unreliable, resulting in inaccurate motor output in this test. Accurate interpretation of proprioceptive information enables adjustment of the internal map of the body's position and movement and forward planning of movement (Ayres, 2005, p94). On a functional level, this would affect the members of the study population's play in ball games and team sports, where they needed to get their body into a position to receive a ball or make contact with another person or object. Academically it may influence their ability to transcribe information from the board or a separate portion of text, as they will not have an accurate internal map from which they can plan movements, or be able to plan and adjust movements based on the information received from their joints and muscles.

Minimum scores for tests of vestibular and proprioceptive processing were consistently low in members of the study population receiving any of the 11 drugs administered. Cytarabine has been documented to cause cerebellar dysfunction, which could adversely influence SWB scores, while L-asparaginase can cause muscle weakness, which may also have had an influence here as it may be difficult to maintain an antigravity posture over a small base of support (Salmi, Toivo T, Äärimaa, Tuula, 2003, p28-31). A study of survivors of ALL, reported these children experiencing difficulties with balance when compares to age and gender matched controls (Salmi, Toivo T, Äärimaa & Tuula, 2003, p28-31).

5.3 SIPT DIAGNOSTIC GROUPS

The SIPT remains one of the most comprehensive and statistically sound assessment tools for measuring a child's sensory processing abilities, especially in tactile discrimination and praxis (Ayres, 2004, p1). This information is particularly valuable when it is enriched by observations of behaviour, and abilities such as supine flexion, prone extension and ocular motor control. Raw scores are entered into a computer, on which the SIPT programme has been loaded and are computed to provide a report which is inclusive of all the scores and SD's and the particular child's scores are also compared to one of six prototypic cluster groups from the normative sample. This data and the compared scores need to be reanalysed and interpreted in the light of behavioural observations (Bundy *et al*, 2002, p171) and other applicable tests available. As previously stated, scores of children with a diagnosed medical condition need to be analysed with caution.

As stated earlier, the members of the study population were assessed on the SIPT, with a subset of them being assessed with the sensory profile caregiver questionnaire.

5.3.1 Low Average Bilateral Integration and Sequencing

A deficit in bilateral integration and sequencing is considered to be present when the major characteristics of the disorder are present i.e. the child obtains low scores in OPr, GRA, SWB, SPr, PPr and BMC, with scores for the other tests in the average range (Ayres, 2004, p132). The contrast between the tests of bilateral integration and the other tests are helpful in identifying this disorder. The SIPT scores of children with a diagnosed medical condition, should be interpreted with caution (Ayres, 2004, p148), and the interpretation may be problematic. This is hypothesised to be a high level sensory integrative based dyspraxia, with difficulties coordinating the two sides of the body and performing projected action sequences due to inefficient processing of vestibular and proprioceptive information. The deficits present may be subtle. Evidence of poor vestibular and proprioceptive processing has to be present for this order to have a sensory integrative dysfunction as a basis (Bundy *et al*, 2002, p81). The members of the study population highlighted in **table 4.16,** meet the criteria for a bilateral integration and sequencing disorder based on the scores in the tests of bilateral function. On closer inspection, none of the three had poor PRN scores, indicating that vestibular information from the semicircular canals was being adequately processed. They did however have low scores in KIN or SWB, measures of proprioceptive processing and processing of vestibular information from the utricle and saccule.

In a study designed to clarify patterns of sensory integration dysfunction, Mailloux *et al* hypothesised that “vestibular functions and bilateral motor coordination and sequencing would be associated, reflecting a pattern of vestibular bilateral integration and sequencing”, (Mailloux *et al*, 2011, p145). This pattern is characterised by low scores in OPr, SWB, PRN, BMC, MAc, GRA, SPr and KIN. Two members of the study population met the criteria for a vestibular bilateral integration and sequencing disorder, due to low scores loading in the aforementioned subtests.

On a functional level, children with difficulty with bilateral integration and sequencing will have difficulty with skills like hopping, skipping, star jumps and jumping with both feet landing together, many of which are used in playground games at school and in play with friends (Bundy *et al*, p180). Once can predict then, that a child with difficulties in this area may have difficulty playing in a way comparable to his peers and may have social difficulties as a result (Bundy *et al*, 2002, p235).

Mixed hand preference, or swapping hands in the performance of a task is an indication of poor bilateral integration and sequencing (Ayres, 2005, p59; Bundy *et al*, 2002, p192, 205). The preferred hand use of members of the study population is represented in **Table 4.25**, with 4 swapping hands during performance of DC, a fine motor visuoconstructional test. This may have occurred due to inefficient specialisation, with the skills for control of hand, finger and thus pencil movements developing in both hemispheres, and inefficient communication between hemispheres occurring. The exchange of preferred hand was facilitated in some cases, by the insertion of a peripheral line administering chemotherapy in the dominant hand. The members of the study population have an innate drive to protect the drip integrity, in order to avoid another painful procedure of venipuncture to reinsert it, and the presence of a foreign body (drip needle) in the hand or forearm provides an uncomfortable sensation, or results in unreliable or dulled information from the tactile and proprioceptive receptors in that hand.

A diagnosis of bilateral integration and sequencing should only be made if there are no other explanations for the low score pattern, such as the presence of somatodyspraxia or a generalised sensory integrative disorder (Bundy *et al*, 2002, p471). The three members of the study population who were highlighted in **table 4.16,** obtained low score clusters in tests of form and space perception and tactile processing, indicating a possible visuo- and/or somatodyspraxia **(cf Table 4.17 and 4.18).** They can thus not be considered to be pure members of a bilateral integration and sequencing disorder group, even though they have definite difficulties in bilateral tasks.

5.3.2 Visuodyspraxia and Somatodyspraxia

Visuodyspraxia is a sensory integrative disorder in which the child obtains low scores on tests of form and space perception, visuomotor and constructional tests (Bundy *et al*, 2002, p472). The information received from the child's eyes (visual system) does not adequately integrate with information from the tactile and proprioceptive system to direct the position of the hands to move or place an object in the correct position in space (Ayres, 2005, p119). This will have an impact on a functional level on the child's ability to learn to write, copy script and diagrams, colour in and participate in activities like join-the-dots, word searches, puzzles and mazes. Ayres highlighted the role of vision in learning, as well as the role of the "hidden" senses of tactile, vestibular and proprioceptive processing in developing the child's understanding of and ability to interact in his world (Ayres, 2005, p179). The presence of visuodyspraxia, with innate difficulties processing visual and proprioceptive information will influence this process and have a negative impact on the child's ability to learn. In analysis of the SIPT scores in this population, there was a marked prevalence of members of the study population possibly presenting with a visuodyspraxia **(cf Table 4.17).**

Somatodyspraxia is a sensory-integrative based dyspraxia, characterised by poor processing of somatosensory information and difficulty in the execution of motor tasks (Bundy *et al*, 2002, p71. 480). It is a more involved type of sensory integrative disorder, with dysfunction evident in many systems, and members of the study population typically receiving low scores in PPr, BMC, SPr, OPr, CPr, PrVC, DC, and MAc as well as the tactile tests (FI, LTS, MFP). Children with somatodyspraxia have difficulty assuming and maintaining the supine flexion posture in clinical observations, which is noted to be prevalent in this population **(cf Table 4.28).** In hand manipulation is also poor in children with somatodyspraxia (Bundy *et al*, 2002, p193). This, along with poor processing of information from the tactile and proprioceptive receptors in the hand, contributes to MFP scores in the dysfunctional range. In part 1, administered to all participants, MFP requires the accurate perception of the shape of a plastic form held in the hand and matching it to a visual stimulus. Information regarding the shape of the plastic form is gained by manipulating it in the hand and feeling it. Poor in hand manipulation would thus have a negative impact on the score. In part 2, somatosensory information from one hand, has to be compared with and matched to somatosensory information from the other hand. This information is received by the child feeling the boundaries of the shape and manipulating the position of his fingers around it. Children with somatodyspraxia have difficulty generalising a motor plan and may tend to compartmentalise skills learnt (Bundy *et al*, 2002, p290), they may appear disorganised in their social interactions, activities of daily living and play skills. These areas of functioning may be further hampered by their inability to manipulate tools and toys adequately for their intended use (Bundy *et al*, 2002, p82). Members of the study population possibly fitting into a group of somatodyspraxia are represented in **Table 4.18**.

Visuodyspraxia and somatodyspraxia can occur concurrently or separately. The SIPT computer generated profile combines these into one group called "visuo-and somatodyspraxia", and closer analysis of the test scores is required to determine if the child has visual dyspraxia with a co-occurring somatodyspraxia or if his score patterns and function can be better explained by one disorder.

In a study designed to clarify patterns of sensory integration dysfunction, Mailloux *et al* (2011) hypothesised that "visual perception and visual praxis would be associated, reflecting a pattern of visuopraxis' and "tactile perception and praxis would be associated, reflecting a pattern of somatopraxis", (Mailloux *et al*, 2011, p145). Patterns of low scores in CPR, MFP, DC, PPr, PrVC and SV are referred to as "visuodyspraxia with some secondary aspects of Somatodyspraxia". Fifteen of the members of the study population diagnosed with visual dyspraxia determined by the original prototypic dysfunctional groups from Ayres's studies with the SIPT, can be considered to have this type of disorder based on their score patterns. It has been reported as a possibility that visuo- and somato-based functions overlap more in samples of children with identified problems (Mailloux *et al*, 2011, p149).

5.3.3 Generalised Sensory Integrative Disorder

A generalised sensory integrative disorder is characterised by low scores in all major areas of testing, i.e. deficits or dysfunction being evident in form and space perception and visuoconstruction, tactile discrimination, praxis and vestibular and proprioceptive processing. There is no definite pattern to the low scores, just a general poor functioning overall. This group could be better described by having severe deficits in somatopraxis, bilateral integration and sequencing, or form and space perception, visuomotor and construction (Bundy *et al*, 2002, p472). Mulligan states in Mailloux *et al*, that "Integration of multiple sensory inputs from multiple sensory systems is important for neurological functioning" (Mailloux *et al*, 2011, p144). **Table 4.19** represents members of the study population who could be considered to have a generalised sensory integrative disorder, indicating a prevalence of 36 % in this population. These members of the study population will have difficulty in many spheres of life, with more effort needed and difficulty experienced in self care activities, play, social interaction, academic learning and regulation of behaviour (Ayres, 2005, p8-10).

5.3.4 Dyspraxia on Verbal Command

Ayres (1989 In Mailloux *et al*, 2011, p144) considered dyspraxia on verbal command to be reflective of left cerebral hemisphere function and not a true sensory integration dysfunction. This dysfunction was present in the standardisation study and included as a SIPT disorder group, probably as a result of inclusion of children with learning difficulties, who tend to have prolonged PRN (score greater than +1SD) (Mailloux *et al*, 2011, p146, 149, 150).

The pattern of scores characterising this disorder is a low score on PrVC, with an average to high score on PRN (Ayres, 2004, p145). Added to this are scores indicative of cerebral inefficiency, seen as low scores in tests requiring bilateral functioning and sequencing abilities with processing of tactile and proprioceptive information (OPr, SPr, BMC, SWB, and GRA).

Table 4.20 highlights the one child who could possibly be included in this diagnostic group based on SIPT scores. **Section 2.5** details neurocognitive effects of childhood cancer treatment, with the development of learning difficulties being named among them.

5.4 PARTIAL PATTERNS OF SENSORY INTEGRATIVE DISORDERS

These partial patterns are based on findings in Ayres standardisation studies of the SIPT, on tests that loaded together (Ayres, 2004, p134).

5.4.1 Partial pattern 1: Inefficient Vestibular Processing associated with poor Visual Processing

This partial pattern, noticed in Ayres original standardisation studies is characterised by low scores in PRN, DC, CPr, SV, FI, MAc, MFP, FG (Ayres, 2004, p134). Movement of the foetus in utero, and subsequent stimulation to gravity receptors in the vestibular system (utricle and saccule) provide the child with early indications of directionality and his position in space. The child needs to learn to understand the dimensions and properties of space around him, starting with his own body and its movement and position. In order to visually perceive objects, the child needs a firm and stable knowledge of the position of the earth and his relation to it, whether he is stationary or moving. This provides the foundation for the child to plan and execute the movement of his body or parts of it through space. Functionally this is seen as the child being able to sit at a table and plan the movement of his upper limb through the space around him while he is holding a pencil in order to write or draw, or to accurately place one lego block on top of another and in relation to other blocks to build a lego house (Ayres, 2005, p116, 117).

In **Section 4.3.3.1, Table 4.21** visually represents members of the study population showing scores in this pattern. The three members of the study population who are indicated with scores matching this pattern are also indicated in **Table 4.17, Table 4.18 and Table 4.19**, as they have score patterns indicative of visuo-dyspraxia with somatodyspraxia and a generalised sensory integrative disorder. No child's score pattern can be exclusively accounted for by partial pattern 1.

5.4.2 Partial pattern 2: Visuoconstruction deficit

This partial pattern is represented by the loading of scores in SV, FG, DC, MAc and CPr, with low scores necessary in two or more of these to consider this deficit (Ayres, 2004, p134).
Details of these tests and the functional implication of poor performance in them are described in **Section 5.2.1**.

In the study done by Mailloux *et al*, on 273 children who had been tested with the SIPT, no evidence was found supporting this partial pattern.

Difficulties in the performance of these subtests would be better accounted for by visuodyspraxia with secondary aspects of somatodyspraxia (Mailloux *et al*, 2011, p148)

5.4.3 Partial pattern 3: Imitative disorder pattern

Postural praxis has been shown to consistently load with factors indicating a link between tactile perception and praxis (Ayres IN Mailloux *et al*, 2011, p148). Oral praxis and Postural praxis have visual component, and their performance will be influenced by visual memory and tactile perception of sensations in and around the mouth, and planning and execution of motor acts respectively. PPr and OPr were determined by Ayres to be a doublet in several analysis (Ayres, 2004, p134, Bundy *et al*, 2002, p472).

Mailloux *et al* do not link these two tests in the analysis of scores completed in their study and do not seem to support the concept of them being a doublet (Mailloux *et al*, 2011, p148).

5.4.4 Partial pattern 4: Vestibulosomatosensory processing deficit

This partial pattern is determined to be an association of low scores in FI, LTS, GRA, KIN, SWB and PRN (Ayres, 2004, p134). No members of the study population obtained score patterns that could solely be accounted for by this partial pattern. Evidence of this pattern is not supported in the study on validity and clarification of patterns of sensory integrative dysfunction (Mailloux *et al*, 2011, p143 – 150).

5.5 HAND SKILLS

Hand skills are essential to enable the child to function in personal care, play and academic skills, and are a primary tool used in interacting with the world around him.

5.5.1 Skilled hand use in SIPT

The somatosensory tests in the SIPT require skilled use of both upper limbs and accurate reception, processing and interpretation of tactile and proprioceptive stimuli (Bundy *et al*, 2002, p43-48).

Slow execution of skills may be as a result of poor in-hand manipulation (Exner, 1990a IN Case-Smith, 2005, p339). Difficulties with in-hand manipulation are also associated with tactile difficulties, praxis and motor control difficulties of the intrinsic muscles of the hand (Exner, 1990a IN Case-Smith, p339). A child who has limited control of isolated finger movements and a limited ability to manipulate and control an object with his finger pads, may have difficulty in performing the MFP test in the time required with sufficient accuracy.

The Manual Form Perception (MFP) part 2 requires the child to use his upper limbs in role differentiated strategies, with one hand holding a stimulus, while the other hand explores a variety of stimuli to find a match. This skill development relies greatly on early childhood development of hand skills in reach, grasp, release and in-hand manipulation (Case-Smith, 2005, p318). The child draws on his motor planning ability, as well as sensory discrimination during the performance of this test as vision is occluded (Case-Smith, 2005, p318).

Difficulties with bilateral hand skills **(cf Table 4.26)** may result from difficulties with motor planning and execution, cognition, bilateral integration of body sides, impaired sensation and motor overflow due to CNS damage or neurological immaturity (Case-Smith, 2005, p293 & p343). Children with cancer, who are receiving chemotherapy through peripheral lines **(cf Figure 4.4,** and **Table 4.29)**, may have decreased sensation in the arm and hand containing the drip. If chemotherapy has leaked into the muscle or soft tissue and caused structural damage, a further decrease in sensation can be expected. This may influence their ability to perform specialised bilateral tasks, where different information is received by each hand or when a different motor action is expected from each hand **(cf Table 4.31).**

The child needs effective hand skills to be able to interact with his environment, handle objects, and engage in childhood occupations of play, self care and schooling (Case-Smith, 2005, p320)
Many childhood play activities require adequate fine motor skills. Among girls, dressing and undressing dolls requires skilled bilateral hand use and object manipulation. Construction games such as building with lego, requires the same range of skills. Boys tend to use specialised bilateral hand skills, often without vision, when playing video games such as playstation (Case-Smith, 2005, p320). Poor bilateral hand skills and difficulty manipulating objects with both hands while vision is partially or fully occluded will have an impact on these children's ability to engage in these games, participate in them with success and interact with their peers in a social situation around such activities.

Specific hand skills needed for the performance of self care skills and activities of daily living are "(1) abilities in grip, (2) the use of two hands in a complementary fashion, (3) the ability to use the hands in varied positions with and without vision, (4) the execution of increasingly complex action sequences, and (5) the development of automaticity" (Henderson, 1995, p181 IN Case-Smith, 2005, p320). Dressing skills, bathing and personal hygiene activities require the use of in-hand manipulation, bilateral upper limb use and grasp patterns (Case Smith, 2005, p320). Children who have difficulties with bilateral hand skills, in hand manipulation and using their hands in a skilled manner to perform these tasks without the assistance and guidance of their visual system, may have difficulty adequately performing these tasks. Children with cancer who have peripheral lines inserted to administer chemotherapy **(cf Section 4.6)** may have significant difficulty performing these tasks due to changes in sensation in the hand, disuse of the hand or pain **(cf Table 4.31).**

Various manipulative activities are included in the classroom. A child receiving formal schooling is expected to remove tools and books from a bag, cut with scissors, fold paper, open glue, paste, colour in, write, erase, and many other activities (Case-Smith, 2005, p321). A child, who has a peripheral line in situ, will have difficulty performing these tasks as they tend to protect the hand with the drip in by not using it. If chemotherapy has leaked into the surrounding tissue and subsequently damages it, sensation and motor skills in the limb will be affected. Difficulty identifying and manipulating objects with vision occluded will hamper the child's ability to locate and remove objects from a school bag or chair bag without unpacking it.

The insertion of a peripheral line for the period of time needed to administer chemotherapy is a temporary obstacle to development. Members of the study population tend to avoid the use of this hand while the drip needle is inserted, swap hand use in fine motor activities and appear in some cases to have altered tactile processing abilities. The long term impact on development is not known at this point.

5.5.2 Preferred hand use

Table 4.25 and **Section 4.2.1** represent and report on preferred hand use in members of the study population. None of the members of the study population chose their left hand as their preferred hand. Preferred hand is determined by the hand the child first chooses to write or draw with. The four members of the study population who swapped hands during performance of fine motor visuomotor tasks (DC or MAc), could have done so due to poor hemispheric specialisation as a result of sensory integrative dysfunction (Ayres, 2005, p59), or due to uncomfortable or painful sensations in that hand **(cf Section 4.4).**

5.6 BEHAVIOURAL RESPONSES TO TESTING

For a child's emotions to be balanced, the limbic system, part of the cerebral hemispheres generating emotionally based behaviour, must receive meaningful and modulated information from the environment (Ayres, 2005, p69).

Behaviours noted in testing are typically due to the child's inability to modulate sensation bombarding him through participation in the test, and to emotionally meet the demands placed on him in the domains of form and space perception, visuomotor construction and construction, tactile processing, praxis and vestibular and proprioceptive processing. If a child is unable to regulate the sensory information being received by his body, he will be unable to regulate his behaviour (Ayres, 2005, p47). Poor modulation may be manifested by "distractibitly, impulsiveness, increased activity level, disorganization, anxiety and poor self-regulation" (Ayres IN Bar-Shalita *et al*, 2005. P148).

Negative emotions and behaviours can be elicited by disruptions in the CNS due to inefficient processing of tactile stimuli, and a hyper responsiveness to this. Striking out at someone, avoidant behaviour (including running away from the situation or refusal), change in mood, and the activation of the fright, flight or fight response are behaviours indicative of tactile defensiveness and activation of the sympathetic nervous system (Ayres, 2005, p 106 – 109, Bundy *et al*, 2002, p108).

The diagnosis of and treatment for childhood cancer is a traumatic event **(cf Section 2.6)** with the child undergoing many painful procedures and experiencing a very real threat to life. Physical pain is caused by procedures including finger pricks, blood tests, bone marrow aspirations, spinal taps and intravenous administration of medication **(cf Section 2.4)**. Stress related symptoms including anxiety, autonomic nervous system hyperarousal, depression, anger, disorganised behaviour and agitation (Mash & Wolfe, 2005, p 362, 363; Kaplan and Sadock, 1998, p619; Butler, Rizzi & Handwerger, 1995, p 499-504; Stuber, Christakis, Houskamp and Kazak, 1996, p254-261). The association between sensory integration, sensory modulation and trauma is apparent in behaviour characterised by hypersensitivity or over arousal, sensory defensiveness, and hyposensitivity or shut down. Anxiety occurring as a direct result of a stressful experience can amplify sensory defensiveness.

Long term hospitalisation and separation from friends, family and social gatherings including school, may result in regression of play behaviour, decreased attention, decreased affect and increased anxiety (Case-Smith, 2005, p577; Kielhofner, Barris, Bauer, Shoestock & Walker, 1983, p305-312). Institutionalisation or hospitalisation of periods longer than 6 months have been shown to result in the development of problems in social behaviours, attention and activity level (Lin *et al*, 2005, p139-147). The reduced opportunities for environmental exploration due to the child beign confined to a bed or chair while receiving intravenous medication, beign hospitalised and thus largely socially isolated, and being kept away from many activities due to fear of injury or infection negatively influences his ability to process and use sensory information to organize, guide and regulate behaviour in later childhood (Lin *et al*, 2005, p139-147).

Table 4.27 visually represents behaviours noted during testing with the SIPT, indicative of difficulties modulating somatosensory information, or coping with the perceptual or practic demands of test items. Signs of autonomic nervous system hyperarousal and the body's response to stress are evident in members of the study population needing to urinate or defecate and a change in respiratory rate. Hypervigilance or heightened arousal are indicative of poor modulation as heightened arousal results in poor performance and the child not being able to make an adaptive response (Bundy *et al*, 2002, p113). Needing to urinate and defecate immediately (this behaviour was usually noted once administration of the tactile tests had started), could be avoidant behaviour or an indication of poor self regulation, both indicative of modulation difficulties. A "shut down” is considered by Royeen and Lane (IN Bar-Shalita *et al*, 2005, p149) to be as a result of a child responding in a defensive manner becoming overloaded with sensory input. Sensory processing is shut down as a protective reaction, and the child appears hyporesponsive.

The ability to modulate sensory input is critical to the child being able to interact with his friends effectively, perform optimally in daily challenges in self care and academic areas, and develop a quality of life (Bar-Shalita *et al*, 2005, p148).

5.7 CLINICAL OBSERVATIONS

Few members of the study population were able to process vestibular information in a way which allows them to smoothly assume and maintain postures of mass flexion (8%) and extension (5%) against gravity, or consistently and smoothly track the path of a moving object in their visual field (29%). Ninety-two percent of members of the study population had some level of difficulty with prone extension, 95 % had difficulty with supine flexion and 71 % had difficulty with ocular pursuits. These difficulties will have a significant impact on their functioning, play and academic learning. Activities at school, such as drawing and writing are challenging for children with poor ocular pursuits as a result of poor vestibular functioning (Ayres, 2005, p63).

5.8 SENSORY PROFILE

A “probable difference” or “definite difference” score indicates that the child responds to items in one or more of six areas of sensory processing in a way that is different to his typically developing peers. The six areas of sensory processing are auditory, visual, vestibular, touch, multisensory and oral sensory. Closer inspection of specific responses and patterns of response frequencies within a section is necessary to accurately determine areas of sensory processing difficulty experienced by the child (Dunn, 2006, p36).

Table 4.44 and **Section 4.8** detail sensory profile findings for the 14 members of the study population whose parents or caregivers completed the caregiver questionnaire. Only 14 of the caregiver questionnaires were useable. Some parents were unable to fill in the questionnaire as they were illiterate, and did not adequately grasp the concepts or understand the questions even when assisted by a translator, or felt the process was too long and tiring to participate in. Others attempted to complete the questionnaire, but left many questions or entire areas blank, making the result invalid or unscorable. Others did not understand the likert scale and tried to write answers to the questions, and other parents took questionnaires, but did not return these top the researcher.

The factor summary scores determining what constitutes “typical performance”, “probable difference” and “definite difference” came out of the factor analysis completed in the American sample used to standardise the sensory profile.

In the factor summary, seeking behaviour indicates that the child has high neurological thresholds, i.e. his CNS takes longer than a typical child’s to respond to incoming stimuli, and this child actively seeks out or looks for and invites stimuli into his systems. Behaviour typical of children seeking sensory input (57% of the sample group responded differently to typical children here) would be tapping their hands on a table, humming, making noises with their mouths, wriggling, chewing on non food items, or touching things excessively (Dunn, 2006, p7, 9).

Poor registration (57% of the sample group responded differently to typical children here) indicates high neurological thresholds, with children not actively seeking sensory input, not working to counteract this threshold and thus missing many environmental cues, such as a friend calling them, their clothing being twisted on their body, shoes being on the wrong feet, a dirty face or hands (Dunn, 2006, p9).

Sensory sensitivity (difference in performance noted in 71% of the sample group) indicates low neurological thresholds, meaning that the CNS responds rapidly to incoming information, and the child attempts to control the influx if this information by making environmental adaptations, like asking people to be quiet, removing a scratchy item of clothing, avoiding certain foods and blocking their ears to incoming noise (Dunn, 2006, p7,9).

The modulation section of the sensory profile gives an indication of how the child is able to combine sensory input from various systems in a way which allows him to function in and participate in his environment. Modulation of body position and movement in the scoring and analysis of the sensory profile includes items of vestibular and proprioceptive processing (Dunn, 2006, p38). There were clear indications of members of the study population having difficulty modulating their behaviour, activity levels and behaviour in the sample group, with more members of the study population displaying behaviour indicating modulation difficulties than those who displayed typical modulated behaviour.

Experiencing challenges with sensory processing can have an impact on emotional responses and behavioural responses to daily events. Scores in the “probable difference” or “definite difference” range indicate that the child is experiencing difficulties adequately processing sensory information, and that this may be resulting in behavioural outbursts or responses considered to be maladapted, out of context or over amplified to the situation (Dunn, 2006, p38). The limbic system must receive modulated information in order to generate emotionally balanced behaviour (Ayres, 2005, p69). A large percentage (57%) of the sample group had performance typical of peers in the emotional and social responses section, while behavioural outcomes and thresholds for responses seemed more atypical. This phenomenon should be closer investigated in another study, to determine possible reasons such as culture influencing it.

5.9 SUMMARY

Results from assessment on the SIPT and sensory profile were discussed with reference to earlier studies and available literature on long term effects of childhood cancer treatment and literature on sensory processing disorders.

SIPT SD scores in domains of function, as determined by the grouping of SIPT tests were discussed. The scores obtained by members of the study population receiving chemotherapy documented in previous studies and the literature review was discussed in each domain of function.

The prevalence of members of the study population in each SIPT diagnostic group was discussed, with the most prevalent disorders being visuo- and somatodyspraxia and generalised sensory integrative disorder. No conclusive results were obtained in analysis of scores in partial patterns of sensory processing disorders.

Behavioural observations made in testing were indicative of difficulties with modulation of sensory information, specifically in the tactile sense, and inability to cope with demands of testing.

Clinical observations made indicate inadequate vestibular and proprioceptive processing, and the possible functional implication of this is discussed.

The hand function, bilateral hand skill test performance and observations made in the behaviour and test scores of members of the study population receiving chemotherapy through peripheral lines is discussed.

CHAPTER 6
-CONCLUSION AND RECOMMENDATIONS-

6.1 LIMITATIONS OF THE STUDY

- The sample group was small (39 children), making generalisation of findings to the childhood cancer population challenging.
- The use of a translator prolonged the test time, often resulting in the test having to be administered over two or three sessions due to the child becoming fatigued.
- Many of the sensory profile caregiver questionnaires had to be discarded as they were incorrectly completed or many areas were left unanswered.
- Praxis on Verbal Command may have been negatively influenced by a language component.

6.2 CONCLUSIONS

- Mean scores in the SIPT were in the dysfunctional range for all subtests. There were members of the study population who obtained scores in the severe dysfunction range in all tests.
- Advanced functioning was noted in some members of the study population in MAc, and LTS.
- There was overall dysfunction in tests of form and space perception, visual motor construction and construction in this population.
- Scores on tests of praxis show variation in results between individual tests, with PrVC scores being the most dysfunctional and OPr obtaining scores within above average ranges.
- Tactile discrimination is affected in a portion of the population.

- Tactile defensiveness is evident in a portion of the population.
- Difficulty in modulating sensory information is evident in the behavioural manifestations in the testing environment and responses to daily activities in a portion of the population.

6.3 RECOMMENDATIONS

- Further study is recommended on a larger sample group to confidently enable generalisation of findings to the childhood cancer population.
- Further investigation into the effect of peripheral line administration of chemotherapy on hand function and tactile discrimination is recommended.
- Further investigation and analysis of sensory processing abilities of children with cancer, using the sensory profile or similar method is recommended.
- Therapeutic intervention using a sensory integration approach is recommended for children receiving treatment for childhood cancer, to address difficulties noted in form and space perception, visuomotor construction, construction, praxis, tactile processing and vestibular and proprioceptive processing as well as modulation of sensory input is recommended.

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Appendix 1

UNIVERSITEIT VAN DIE VRYSTAAT
UNIVERSITY OF THE FREE STATE
YUNIVESITHI YA FREISTATA

Direkteur: Fakulteitsadministrasie / Director: Faculty Administration
Fakulteit Gesondheidswetenskappe / Faculty of Health Sciences
Research Division
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Ms H Strauss

2007-09-14

MS G LOUDON
P O BOX 50948
WIERDA PARK
CENTURION
0149

Dear Ms Loudon

ETOVS NR 137/07
INVESTIGATOR: MS G LOUDON
PROJECT TITLE: PREVALENCE AND ASSOCIATIONS OF SENSORY INTEGRATIVE DISORDERS AMONG THE CHILDHOOD CANCER POPULATION.

- You are hereby informed that The Ethics Committee approved the above-mentioned study at the meeting held on 11 September 2007
- Committee guidance documents: Declaration of Helsinki, ICH, GCP and MRC Guidelines on Bio Medical Research. Clinical Trial Guidelines 2000 Department of Health RSA; Ethics in Health Research: Principles Structure and Processes Department of Health RSA 2004; the Constitution of the Ethics Committee of the Faculty of Health Sciences and the Guidelines of the SA Medicines Control Council as well as Laws and Regulations with regard to the Control of Medicines.
- Any amendment, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.
- The Committee must be informed of any serious adverse event and/or termination of the study.
- A progress report should be submitted within one year of approval of long-term studies and a final report at completion of both short term and long term studies.
- Please refer to the ETOVS reference number in correspondence to the Ethics Committee secretariat.

Yours faithfully

for **PROF BB HOEK**
CHAIR: ETHICS COMMITTEE

Appendix 2

Dear Applicants

Your ethics application has been approved and your clearance certificate is ready for collection in Room 10004, 10th Floor, Senate House.

Pam Kissane

Secretary

Human Research Ethics Committees.

Tel (011) 717-1234

Fax (011) 717-1265

e-mail anisa.keshav@wits.ac.za

For ethics information and forms please go to www.wits.ac.za/research/forms

ethics certificate - please could you assist with this ?

Friday, 27 May, 2011 12:48

From:

"Gina Loudon" <ginaloudon@yahoo.co.uk>
Add sender to Contacts

To:

Anisa.Keshav@wits.ac.za

Hi Anisa,
please could you assist in the following matter ?
kind regards
Gina

--- On **Wed, 25/5/11, Gina Loudon <*ginaloudon@yahoo.co.uk*>** wrote:

From: Gina Loudon <ginaloudon@yahoo.co.uk>
Subject: ethics certificate
To: Anisa.Keshav@wits.ac.za
Date: Wednesday, 25 May, 2011, 11:41

Good Morning Anisa,
I have misplaced my ethics clearance certificate for protocol **M071016.**
Please could you email me a copy?
My master’s thesis has to be in on Friday, and this needs to be in the appendix.
I am unable to collect one as I have moved to Durban.
Sorry for the inconvenience, hope you can assist me with this.
kind regards
Gina Loudon
082 665 8385

Appendix 3

The Research Ethics Committee, Faculty Health Sciences, University of Pretoria comply with ICH-GCP guidelines and has US Federalwide Assurance. FWA 00002567, Approved dd 22 May 2002 and Expires 24 Jan 2009.
IRB 0000 2235 IORG0001762 Approved dd Jan 2006 and Expires 21 Nov 2008.

Universiteit van Pretoria
University of Pretoria

Faculty of Health Sciences Research Ethics Committee
University of Pretoria
HW Snyman Building, (South)　Private Bag X169
Level 2-34　Pretoria

Date: 2/10/2007

PROTOCOL NO.	**121/2007**
ATTATCHEMENDS	• Cover Letter ✓ • Curriculum Vitae of Principal ✓ • Declaration of Helsinki. ✓ • Full protocol. ✓ • Budget layout✓ • Gauteng Application form. ✓ • Harmonized Document. ✓ • Letter of Intent. ✓ • Permission to Access files/data base at KALAFONG HOSPITAL; JHB; and UNIVERSITAS hospitals. ✓ • Permission from Chief Executive Officer of UNIVERSITAS; KAKAFONG; JHB Hospitals. ✓ • Patient Information Leaflet Informed Consent forms. (Eng, Afr. 2 black languages) ✓ with translators of UNISA✓ • Data Capturing form. ✓
PROTOCOL TITLE	Examining the prevalence and association of sensory integrative disorders among the childhood cancer population
INVESTIGATOR	**Person:**Gina Loudon **Phone: Fax: E-Mail:** ginaloudon@yahoo.co.uk **Cell:**0826658385
DEPARTMENT	Pediatric Occupational Therapy
STUDY DEGREE	Masters in Occupational Therapy
SUPERVISOR	Mrs Annamarie van Jaarsveld
SPONSOR	None.
COMPLETE POSTAL ADDRESS	Kalafong Hospital ; University of Pretoria; Pretoria
MEETING DATE	26/09/2007

This Protocol and Informed Consent and all the attatchemnts have been considered by the Faculty of Health Sciences Research Ethics Committee, University of Pretoria on 26/09/2007 and found to be acceptable.

*Advocate AG Nienaber	(female)BA(Hons) (Wits); LLB; LLM (UP); Dipl.Datametrics (UNISA)
Prof V.O.L. Karusseit	MBChB; MFGP (SA); M.Med (Chir); FCS (SA): Surgeon
Prof M Kruger	(female) MB.ChB.(Pret); Mmed.Paed.(Pret); PhDd. (Leuven)
Dr N K Likibi	MB.BCh.; Med.Adviser (Gauteng Dept.of Health)
Snr Sr J. Phatoli	(female) BCur (Et.Al) Senior Nursing-Sister
*Dr L Schoeman	(female) Bpharm, BA Hons (Psy), PhD
*Prof J.R. Snyman	MBChB, M.Pharm.Med: MD: Pharmacologist
*Dr R Sommers	(female) MBChB; M.Med (Int); MPhar.Med;
Prof TJP Swart	BChD, MSc (Odont), MChD (Oral Path) Senior Specialist; Oral Pathology
*Dr A P van Der Walt	BChD, DGA (Pret) Director: Clinical Services of the Pretoria Academic Hospital
*Prof C W van Staden	MBChB; Mmed (Psych); MD; FTCL; UPLM; Dept of Psychiatry

DR R SOMMERS; MBChB; M.Med (Int); MPhar.Med.
SECRETARIAT of the Faculty of Health Sciences Research Ethics Committee - University of Pretoria

* = Members attended the meeting on 26/09/2007.

C:\Users\admin\Documents\thesis\ethics approval UP.doc

PREVALENCE AND ASSOCIATIONS OF SENSORY INTEGRATIVE DISORDERS IN THE CHILDHOOD CANCER POPULATION

MARK THE APPROPRIATE BLOCK WITH AN "X"
OR WRITE YOUR ANSWER IN THE SPACE PROVIDED

IDENTIFICATION CODE:_______________________ ☐☐ 1 - 2

1 Evaluation date________________________________ ☐☐☐☐☐☐ 3-8
d d m m y y

2 Birthdate_______________________________________ ☐☐☐☐☐☐ 9-14
d d m m y y

3 Age____ ☐☐☐☐ 15-18
y y m m

4 Gender: ☐ 19
(1) Male ☐
(2) Female ☐

5 Hand preference: ☐ 20
(1) Left ☐
(2) Right ☐
(3) Both ☐

6 If attending school; grade______________________ ☐ 21
(1) creche/ preschool ☐
(2) grade 0 ☐
(3) grade 1 ☐
(4) grade 2 ☐
(5) grade 3 ☐

7 Ethnicity: ☐ 22
(1) White ☐
(2) Black ☐
(3) Coloured ☐
(4) Asian ☐
(5) Indian ☐

8 Home Language: ☐ 23
(1) English ☐
(2) Afrikaans ☐
(3) South Sotho ☐
(4) North Sotho ☐
(5) Zulu ☐
(6) Xhosa ☐
(7) Other (specify)_______________________ ☐

9 Primary Cancer Diagnosis: ☐ ☐☐ 24-25
(1) Neuroblastoma ☐
(2) Wilms Tumour ☐
(3) Germ Cell Tumour ☐
(4) Rhabdomyosarcoma ☐
(5) Osteosarcoma ☐
(6) Retinoblastoma ☐
(7) Acute Lymphoblastic Leukemia
7a) Early Pre-B cell ☐
7b) Pre-B cell ☐
7c) Mature B cell ☐
7d) cALL ☐
(8) Acute Myloid Leukemia
8a) M0 ☐
8b) M1 ☐
8c) M2 ☐
8d)M3 ☐
8e)M4 ☐
8f)M5 ☐
8g)M5a ☐
8h)M5b ☐
8i)M6 ☐
8j)M7 ☐
(9) Hodgkins Lymphoma ☐
(10) Non-Hodgkins Lymphoma ☐
(11) Other(specify)______________________ ☐

10 Stage/ Risk ☐ 26
10.1 Solid Tumours ☐
(1)stage 1 ☐
(2)stage 2 ☐
(3)stage 3 ☐
(4)stage 4 ☐
10.2 Leukaemia ☐ ☐ 27
(1)low risk ☐
(2)intermediate risk ☐
(3)high risk ☐

11 Date of Diagnosis:______________________________ ☐☐☐☐☐☐ 28-33
d d m m y y

12 Chemotherapy received:
(1) Bleomycin/ Blenoxane/ BLM ☐ ☐☐ 34-35
(2) Carboplatin/ Paraplatin ☐ ☐☐ 36-37
(3) Cisplatin/ CDDP/ Cisplatinum/ Platinol ☐ ☐☐ 38-39
(4) Cyclophosphamide/ Cytoxan ☐ ☐☐ 40-41
(5) Cytarabine/ ARA-C/ Cytosar/ Cytosine arabinase ☐ ☐☐ 42-43
(6) Dacarbazine/ DTIC-Dome ☐ ☐☐ 44-45
(7) Dactinomycin/ Actinomycin D/ Act D/ Cosmegen ☐ ☐☐ 46-47
(8) Daunorubicin/ Daunomycin/ DMN/ DNR/ Cerubidine/ Rubidomycin ☐ ☐☐ 48-49
(9) Dexamethasone/ Decadron ☐ ☐☐ 50-51
(10) Doxorubicin/ Adriamycin/ Doxil/ Rubex ☐ ☐☐ 52-53
(11) Etoposide/ VP-16/ VePesid/ Etopophos/ Toposar ☐ ☐☐ 54-55
(12) Idarubicin/ Idamycin ☐ ☐☐ 56-57
(13) Ifosfamide/ Ifex/ IFF ☐ ☐☐ 58-59
(14) L-Asparaginase/ L-Asp/ Asp/ Elspar ☐ ☐☐ 60-61
(15)Mercaptopurine/ 6-MP/ Purinethol ☐ ☐☐ 62-63
(16) Methotrexate/ Methotrex/ MTX ☐ ☐☐ 64-65
(17) Prednisone ☐
(18) Tretinoin/ ALL-trans-retionic acid/ ATRA/ vesanoid ☐
(19) Vincristine/ oncovin/ VCR ☐
(20) Vinblastine/ VLB/ velban ☐
(21) 6-thioguanine/ 6-TG ☐
(22) 5-FU/ 5-fluorouracil/ Adrucil ☐
(23) Intrathecal methotrexate ☐
(24) intrathecal cytosar ☐
(25) intrathecal hydrocortisone ☐
(26) other (specify)_________________ _________________ ☐
(27) ________________________ _________________ ☐
(28) ____ ☐

13 administration method ☐ 66
(1) peripheral line left arm ☐ ☐ 67
(2) peripheral line right arm ☐
(3) portocath ☐
(4) hickman line ☐
(5) other (specify)_________________________ ☐

14 Sensory profile findings
(1)Typical performance
(2) Probable difference
(3) Definite difference

14.1 Factor summary
14.1.1 Sensory Seeking ☐ ☐ 68
14.1.2 Emotionally Reactive ☐ ☐ 69
14.1.3 Low Endurance/Tone ☐ ☐ 70
14.1.4 Oral Sensory Sensitivity ☐ ☐ 71
14.1.5 Inattention/Distractability ☐ ☐ 72
14.1.6 Poor Registration ☐ ☐ 73
14.1.7 Sensory Sensitivity ☐ ☐ 74
14.1.8 Sedentary ☐ ☐ 75
14.1.9 Fine Motor/Perceptual ☐ ☐ 76

14.2 Sensory processing			
14.2.1 Auditory	☐	☐	77
14.2.2 Visual	☐	☐	78
14.2.3 Vestibular	☐	☐	79
14.2.4 Touch	☐	☐	80
14.2.5 Multisensory	☐	☐	1
14.2.6 Oral Sensory	☐	☐	2
14.3 Modulation			
14.3.1 Sensory processing related to endurance/tone	☐	☐	3
14.3.2 Modulation related to body position and movement	☐	☐	4
14.3.3 Modualtion of movement affecting activity level	☐	☐	5
14.3.4 Modulation of sensory input affecting emotional responses	☐	☐	6
14.3.5 Modul of visual input affect emotion respons and activity level	☐	☐	7
14.4 Behavioural and emotional responses			
14.4.1 Emotional/ Social Responses	☐	☐	8
14.4.2 Behavioural Outcomes of Sensory Processing	☐	☐	9
14.4.3 Items indicating Thresholds for Response	☐	☐	10
14.5 Sensory processing based on neurological Thresholds and behavioural response patterns			
(1) less than others definite difference			
(2) less than others probable difference			
(3) typical performance			
(4) more than others probable diference			
(5) more than others definite difference			
14.5.1 Poor Registration	☐	☐	11
14.5.2 Sensitivity to Sensory Stimuli	☐	☐	12
14.5.3 Sensation Seeking	☐	☐	13
14.5.4 Sensation Avoiding	☐	☐	14
15 clinical observation findings			
15.1 Tactile defensiveness			
(1)No defensive responses	☐	☐	15
(2) Mild defensiveness	☐		
(3) Moderate defensiveness	☐		
(4) Severe defensiveness	☐		
15.2 Prone extension		☐	16
(1) Poor	☐		
(2) Slightly deficient	☐		
(3) Adequate	☐		
15.3 Supine flexion			
(1) Poor	☐	☐	17
(2) Slightly deficient	☐		
(3) Adequate	☐		
15.3 Ocular pursuits			
(1) Poor	☐	☐	18
(2) Slightly deficient	☐		
(3) Adequate	☐		
16 Behavioural responses during testing			
(1) yawning	☐	☐☐	19-20
(2) respiratory rate change	☐	☐☐	21-22
(3) need to urinate	☐	☐☐	23-24
(4) need to defecate	☐	☐☐	25-26
(5) sleeping soon after test	☐	☐☐	27-28
(6) crying	☐	☐☐	29-30
(7) increased levels of anxiety	☐	☐☐	31-32
(8)lying on arms	☐	☐☐	33-34
(9) irritability	☐	☐☐	35-36
(10) hypervigilance	☐	☐☐	37-38
(11) drop in mood	☐	☐☐	39-40
(12) “shut down”	☐		
(13) verbal outbursts	☐		
(14) avoidant behaviour	☐		
(15) running away	☐		
(16) change in preferred hand use	☐		
(17) wriggling	☐		
(18) other(specify) ___________________________	☐		