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THE RELATIONSHIP BETWEEN DEVELOPMENTAL DYSPRAXIA AND SENSORY RESPONSIVITY IN CHILDREN AGED FOUR YEARS THROUGH EIGHT YEARS

by

KARIN BUITENDAG

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Supervisor: Mrs MC Aronstam

DECLARATION

I, Karin Buitendag, hereby declare that this dissertation is my own, original work. Where someone else's work was used (whether from a printed source, the internet or any other source) due acknowledgement was given and reference was made according to requirements. I further declare that this dissertation which I submit for the degree MOcc Ther at the University of Pretoria has not previously been submitted by me for a degree at another university.

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Date

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SUMMARY

KEYWORDS

Developmental Dyspraxia, Sensory Modulation Dysfunction, Sensory Integration, sensory responsivity, Sensory Profile, Sensory Profile School Companion, Sensory Integration and Praxis Tests, sensory under- or over-responsivity

Developmental Dyspraxia and Sensory Modulation Dysfunction are Sensory Integration Disorders that are widely known to occupational therapists practicing in the paediatric occupational therapy field. These disorders have been the subject of numerous research studies that have managed to clarify and explain relations of these disorders with sensory processing as well as their prevalence in different diagnostic groups. Such a clarified relationship is between Developmental Dyspraxia and Sensory Discrimination, while Sensory Modulation Dysfunction is reported to occur in various diagnostic groups.

Developments over the past decade in the field of Sensory Integration proposed that Developmental Dyspraxia and Sensory Modulation Dysfunction be regarded as two patterns of a Sensory Processing Disorder and suggested that these two disorder patterns occurred concomitantly. Clinical experience, however, resulted in the researcher questioning the above proposed concomitant relationship and hypothesised that there was a specific relation between Developmental Dyspraxia and Sensory Responsivity (Sensory Modulation Dysfunction).

This study was directed at investigating the relationship between Developmental Dyspraxia and Sensory Responsivity. A review of the literature that described these two disorder patterns yielded reference to theories that underpin Developmental Dyspraxia and Sensory Responsivity. From these theories it was possible to identify some common ground between Developmental dyspraxia and Sensory Responsivity that could potentially support a relation.

The Sensory Profile, Sensory Profile School Companion and the Sensory Integration and Praxis Tests were used to assess and identify Developmental Dyspraxia and Sensory Responsivity. Obtained data were statistically analysed and compared and did not produce a statistically significant positive relation between Developmental Dyspraxia and Sensory Responsivity, but yielded some weak correlations in supplementary analysis. These weak correlations have value in terms of sensory responsiveness tendencies in the presence of types of dyspraxia.

Clinical analyses of the data set were performed to examine the incidence of types of dyspraxia in the sample with sensory over- or under responsiveness. These analyses demonstrated a greater presence of Developmental Dyspraxia in the population with Sensory Under-responsivity. The clinical analyses provided the researcher with additional information that was taken into account when conclusions were made. It also contributed to the recommendations that were made at the end of Chapter 5.

Discussion of results was directed at explaining correlations and interpreting the implications of those correlations. A discussion of possible problems included considering possible flaws in the method and procedure that could have contributed to the research outcome. Recommendations were directed at proposals for future research and recommendations for clinical practice.

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ABBREVIATIONS USED

ADHD	Attention Deficit Hyperactivity Disorder
ANOVA	Analysis of Variance
ASD	Autism Spectrum Disorder
BIS	Bilateral Integration and Sequencing
CAS	Childhood Apraxia of Speech
CNS	Central Nervous System
CPr	Constructional Praxis
DC	Design Copying
DD	Developmental Dyspraxia
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders IV
EMSM	Ecological Model of Sensory Modulation
FG	Figure Ground
KIN	Kinaesthesia
KSPT	Kaufman Speech and Praxis Test for children
LIH	Longer Institutionalised Child
LTS	Localisation of Tactile Stimuli
MAc	Motor Accuracy
MFP	Manual Form Perception
M	Mean
OT	Occupational Therapist
PDMS-2	Peabody Developmental Motor Scales
PRN	Post Rotary Nystagmus
PrVc	Praxis on Verbal Command
SBMD	Sensory Based Motor Disorder
SCSIT	Southern California Sensory Integration Test
SD	Standard Deviation
SEM	Standard Error of Measurement
SIH	Shorter Institutionalised Child
SIPT	Sensory Integration and Praxis Tests

SMD	Sensory Modulation Disorder
SOR	Sensory Over Responsiveness
SPD	Sensory Processing Disorder
SP	Sensory Profile
SPSC	Sensory Profile School Companion
SUR	Sensory Under Responsiveness
SV	Space Visualisation
SWB	Standing Walking Balance
USA	United States of America

CHAPTER 1

RESEARCH ORIENTATION

1.1 INTRODUCTION TO SENSORY INTEGRATION

Developmental Dyspraxia and Sensory Modulation Dysfunction are disorders that are widely recognised and acknowledged in the occupational therapy domain, but have not yet been included in the DSM-IV.[1] The constructs underpinning these disorders evolved from the work of A Jean Ayres in the late 1960's, who investigated the way the brain processes sensory information. The Theory of Sensory Integration developed as a result of Ayres' work with learning-disabled children who displayed deficits in interpreting sensation. She wanted to explain the relationship between deficits in processing sensation from the body and difficulties with academic and motor learning.[2]

The term Sensory Integration is used in various contexts by occupational therapists worldwide. In some instances it is used in a particular way to view neural organisation of sensory information for functional behaviour. In other cases it is used as a clinical frame of reference for assessment and treatment of people with functional disorders in sensory processing.[3] Ayres believed that the integration of sensation within the central nervous system (CNS) provides an important foundation for individuals to engage in meaningful, health-promoting occupations that support participation in life.[4,5] She defined sensory integration as the behavioural manifestation of adequate sensory reception, registration and synthesis.[6]

Conversely, when a problem with processing sensation occurs and it results in problems in planning and function, Sensory Integrative Dysfunction is likely to be present. Sensory Integration Dysfunction is thus the inability to modulate,

discriminate, coordinate or organise sensations adaptively. Sensory Integration Dysfunction can be described in terms of observable behaviours that reflect a child's impaired ability to interact effectively or efficiently within the demands of his culture, environment, relationships or tasks.[7]

In her quest to identify and describe Sensory Integration Dysfunction, Ayres initiated extensive research to develop a measurement instrument of Sensory Integration. Through empirical research[3] Ayres attempted to validate her hypotheses regarding brain behaviour, processing of sensation and the subsequent relationship with dysfunction. Her research mostly focused on finding ways to identify patterns of Sensory Integrative Dysfunction. Two major measurements of Sensory Integration subsequently emerged, namely the Southern California Sensory Integration Test (SCSIT) in 1972[3] followed by the Sensory Integration and Praxis Tests (SIPT) in 1989.[2]

One of the patterns of Sensory Integration Dysfunction that is of relevance to this study is Developmental Dyspraxia, which can be identified with the SIPT. Children who present with Developmental Dyspraxia often have trouble coping with life situations, including childhood occupations like play, academic learning and social behaviour.[8]

Another pattern of Sensory Integration Dysfunction that is of relevance to this study is Sensory Modulation Dysfunction (SMD), which can be identified with the Sensory Profile (SP). Sensory Modulation Dysfunction is a pattern of Sensory Integration Dysfunction in which a person under- or over-responds to sensory input from the body and environment.[6] Although described by Ayres in her earlier body of work, Sensory Modulation Dysfunction cannot be identified with the SIPT. It is only in recent years that Sensory Modulation Dysfunction has been the focal point of researchers who expanded on Ayres' existing model of sensory modulation and proposed new models of viewing Sensory Modulation Dysfunction.

Not only has Ayres' contribution to the field of sensory integration paved the way for continued research, it also led to the development of additional constructs pertaining to Sensory Integration. As the body of work on this subject continued to grow and was expanded upon, some terminology and classification changes took place to accommodate new and emerging concepts. One on these terms that emerged in recent years is the term Sensory Processing, which is frequently used to describe sensory-based processing.[9] Sensory Processing is an encompassing term that refers to the way in which the CNS and the peripheral nervous system manage incoming sensory information from peripheral sensory systems.[10]

This progression to the use of the term Sensory Processing resulted in the use of the term Sensory Processing Disorder to describe sensory-based processing challenges explained in neurophysiologic and behavioural terms. The behavioural expressions of Sensory Processing Disorders were recently organised in a classification of "patterns and sub-patterns" of dysfunction.[9] According to Miller, Anzalone, Lane, Cermak and Osten[9], Sensory Processing Disorder is divided into "patterns and sub-types" of disorders. For the purpose of uniformity and clarification, the researcher proposes the use of the terms "patterns and sub-patterns" instead of "patterns and sub-types". The constructs under investigation in this study, namely Developmental Dyspraxia and Sensory Modulation Dysfunction, are included in the classification structure proposed by Miller et al (see Figure 1).

The terms Sensory Modulation Dysfunction and Sensory Modulation Disorder are used interchangeably in this study. In this study, Sensory Modulation Dysfunction refers to deficiency in sensory modulation and Sensory Modulation Disorder refers to the behavioural expressions of deficient sensory modulation (see Figure 1). These terms are used in context and applied to best describe or clarify a point or statement.

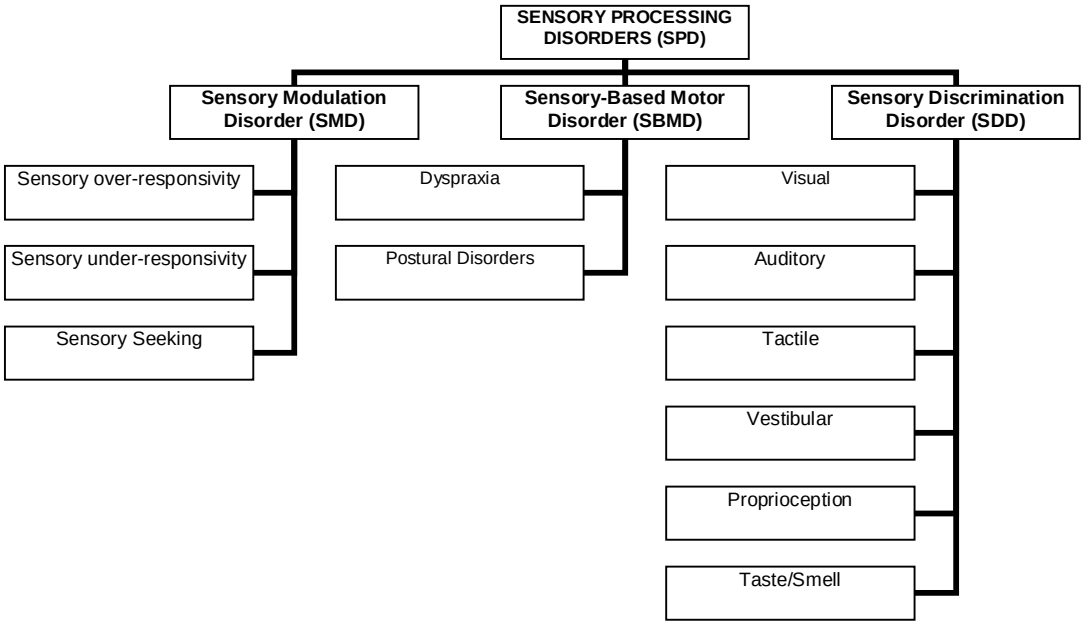

Figure 1.1 Classification of Sensory Processing Disorders Patterns and Sub-patterns

1.2 BACKGROUND TO THE RESEARCH PROBLEM

Application of a sensory integration framework in clinical practice, specifically during assessment and treatment of children with Sensory Processing Disorder, has resulted in the researcher observing that different patterns and sub-patterns of Sensory Processing Disorder occur concomitantly. Assessment of sensory processing abilities often revealed that Developmental Dyspraxia occurred together with a disorder in sensory discrimination. Another relation that was observed was between Developmental Dyspraxia and Sensory Modulation Disorder.

Investigation of the kinship of Developmental Dyspraxia with a disorder in Sensory Discrimination through a review of literature revealed empirical research that validates this relationship. Fisher, Murray and Bundy[11] emphasised the relationship between deficits in sensory processing (sensory discrimination) and Developmental Dyspraxia. Poor sensory discrimination is thus linked to

Developmental Dyspraxia. Factor analysis of the SCSIT (1972) and the SIPT (1989 and 1998) have revealed a repeated association between tactile discrimination and motor planning.[11,12] Data from factor analysis of SIPT scores further reaffirmed the close relationship between tactile processing and practic abilities.[13]

Review of literature that validates or supports a relationship between Developmental Dyspraxia and Sensory Modulation Dysfunction did not yield empirical evidence. There are, however, related theories in literature that offer motivation to pursue and explore scientific analysis and reasoning to examine such a relationship. Sensory Modulation Disorder is divided into three sub-patterns. These sub-patterns reflect behaviour that either indicates under- or over-responsiveness to sensory input or sensory-seeking behaviour. The sub-patterns of sensory under- or over-responsiveness are of importance to this study.

An important process in sensory modulation is noticing or detecting sensory input, and this process occurs centrally. Sensory detection and subsequent processing of information are intimately related. Thus, to allow for sensory information to be handled in a routine and orderly manner (processed), it has to be detected first.[6]

The Information Processing Model developed by Schmidt[1] in 1991 relates movement planning to information processing. The first step of information processing is stimulus identification and is divided into sensing (detecting), encoding and perceiving significant environmental stimuli. Although mention is made of detecting sensory input, little emphasis is placed on this step of stimulus identification and the importance of detecting sensory information for accurate and precise interpretation.

The nature of the relationship between Developmental Dyspraxia and Sensory Modulation Dysfunction has, to date, not been clarified except to view these sub-patterns of dysfunction as two different expressions of sensory processing disorder. A void exists in occupational therapy literature to describe and explain how sensory modulation impacts on sensory discrimination and consequently on praxis. Sensory Modulation Dysfunction and Developmental Dyspraxia have been researched as separate entities, but the relationship between the two has not yet been investigated through empirical research.

Closer scrutiny of the classification of Sensory Processing Disorder to provide a scientific foundation for the research study highlighted shortcomings when it is used in an academic rather than a clinical application. The classification, indicated in Figure 1.1, depicts Sensory Processing Disorder as an umbrella term with three emerging patterns, which are: Sensory Modulation Disorder (SMD), Sensory-based Motor Disorder (SBMD) and Sensory Discrimination. The arrangement of these patterns in the figure suggests that they are of equal standing and each could theoretically be a singular disorder. The first two patterns are indicated as disorders, but “Sensory Discrimination” does not represent a disorder. Each of these patterns is divided into sub-patterns that do not seem to have equal standing in terms of independent entities as disorders or sub-disorders. A mixture of characteristics such as neurological thresholds, behaviour, disorders and sensory systems are assembled in the sub-patterns. Clinically it is encountered that children often present with a combination of these patterns or sub-patterns, which suggests that they occur concomitantly. From a scientific point of view, this inequality of entities in the classification creates a complex scenario which does not support the scientific investigation of relationships.

The previously mentioned observation (page 4) by the researcher in the clinical setting resulted in the researcher identifying the need to investigate the prevalence of sensory under- or over-responsivity in children diagnosed with

Developmental Dyspraxia. Murray-Slutsky and Paris[14], in their discussion of Developmental Dyspraxia, postulate that a failure to register the necessary sensory information impacts on the child's ability to develop an idea or plan of what to do (ideation in praxis). Ayres also stated that sensory information from the body and environment is necessary in initial intake of information before the decision to act takes place (ideation).[15] Murray-Slutsky and Paris view decreased sensory responsivity to touch or proprioceptive input as a secondary problem in developmental dyspraxia.[14]

The researcher, however, hypothesises that sensory under- or over-responsivity could be a primary problem associated with dyspraxia. The nature of the relationship between Developmental Dyspraxia and Sensory Responsivity is therefore a subject that needs investigation and further exploration. Further research is needed in the field of Sensory Integration to investigate relationships amongst different patterns and sub-patterns that occur under Sensory Processing Disorder. Empirical data on different relationships is also needed to further revise the contemporary classification.

1.3 PROBLEM STATEMENT AND RESEARCH QUESTION

Children with sensory under-responsivity tend to respond less to sensory stimuli in their environment. In other words, they appear to have decreased detection of incoming sensory information. Children with sensory over-responsivity, on the other hand, tend to respond to sensation faster, with more intensity or for a longer duration than those with typical responsivity.[9] Herein lies the problem: Developmental Dyspraxia is closely and consistently related to poor sensory discrimination as established through empirical research by Ayres and Mulligan[16], but the question arises as to the relationship between Developmental Dyspraxia and Sensory Responsivity.

It is with the above in mind that the following research question was formulated:

Is there a relationship between Developmental Dyspraxia and Sensory Responsivity?

1.4 RESEARCH AIM AND RESEARCH OBJECTIVES

1.4.1 Research Aim

The aim of this research study was to investigate the relationship between Developmental Dyspraxia and Sensory Responsivity.

1.4.2 Research Objectives

To establish if Developmental Dyspraxia is related to Sensory Under-responsivity or Sensory Over-responsivity.

To determine if specific types of Developmental Dyspraxia are related to Under-responsivity or Over-responsivity in specific sensory systems.

To investigate if specific items on the Sensory Profile and School Companion are related to specific types of Developmental Dyspraxia.

1.5 DEFINITION AND CLARIFICATION OF CONCEPTS

The following relevant terms were used in this research study and are explained for clarification:

Praxis is the ability to conceptualise, plan and execute a non-habitual motor act.[3] Problems with praxis are often referred to as dyspraxia.

Developmental Dyspraxia is a developmental difficulty with planning unfamiliar movements resulting from poor body scheme, which, in turn, is based on poor processing of sensation, especially visual, vestibular, proprioceptive and tactile.[17] Children who present with dyspraxia may experience difficulty with the following aspects of praxis:

- **Ideation** is conceptualising an action; knowing what to do.
- **Motor planning** involves organising sensory information to formulate and sequence a plan of action.
- **Motor execution** takes place once the ideation and motor planning have occurred. Motor execution is the motor performance of an action and it is through the motor act that the quality of ideation and motor planning can be observed.[18]

Sensory Modulation is the ability of the nervous system to regulate, organise and prioritise incoming sensory information, inhibiting or suppressing irrelevant information and helping a person to focus on relevant information.[19]

Sensory Modulation Disorder is a problem in regulating and organising the degree, intensity and nature of responses to sensory input in a graded manner.[20]

Sensory Modulation Dysfunction is a pattern of dysfunction of sensory integration in which a person under- or over-responds to sensory input from the body or environment.[17] The term Sensory Modulation Dysfunction is used interchangeably with Sensory Modulation Disorder in Sensory Integration literature and is also used interchangeably in this literature review. Preference is given to the term Sensory Modulation Dysfunction when referring to dysfunction of modulation whereas Sensory Modulation Disorder is used to refer to the sub-patterns of deficits in sensory modulation.

Sensory under-responsivity (SUR) is the tendency to exhibit less of a response to sensory information than the situation demands, taking longer to react or requiring relatively long-lasting sensory messages before action is generated.[15]

Sensory over-responsivity (SOR) is the tendency to respond to sensation faster, with more intensity or for a longer duration.[9]

Sensory detection refers to the neurophysiological process of detecting sensory information. It is the first step in a neurophysiological process that occurs centrally, where incoming sensory information is recorded at multiple levels within the CNS so that it can affect ongoing neuronal activity by influencing the overall level of activity in the CNS.[10] The use of the term sensory detection is recommended by Lane, Miller and Haft to label the process of taking in and recording sensory information from the environment and to include CNS activities.[6] Preference is given to the use of the term sensory detection in this research study so that detecting and recording of sensory information also includes CNS activity.

Sensory registration is noticing sensory stimuli in the environment.[17] It is often used to describe failure to register sensory information from the environment. Consensus by a group of experts in 2002[9] advised against the use of the term sensory registration as it is not clearly defined in neurophysiological literature.

Sensory discrimination is the central process of distinguishing between and organising temporal and spatial characteristics of sensory stimuli.[10]

Sensory Processing Disorder is difficulty with functions related to sensation occurring in the CNS and includes reception, modulation, integration and organisation of sensory stimuli. It also includes difficulty with behavioural responses to sensory input.[17]

Sensory Integration Dysfunction is difficulty with CNS processing of sensation, specifically tactile, vestibular or proprioceptive, which is manifested as poor praxis, poor modulation or both.[17]

1.6 SIGNIFICANCE AND CONTRIBUTION OF THIS RESEARCH

Occupational therapy literature[1,11,13] that describes Developmental Dyspraxia refers specifically to the close relationship between deficits in sensory discrimination and developmental dyspraxia. Literature on sensory modulation[19] describes the types of Sensory Modulation Disorders and relevant intervention approaches. Although Developmental Dyspraxia and Sensory Modulation Disorders are acknowledged to occur concomitantly, a gap exists in literature that describes the nature of the relationship between Sensory Responsivity and Developmental Dyspraxia. The aim of this study was to provide empirical research data that could assist in clarifying the nature of the relationship between Developmental Dyspraxia and Sensory Responsivity. Data obtained from this study could be used to fill a gap in occupational therapy literature through confirmation of a relationship and by describing the nature of such a relationship and thus provide valuable information that has been lacking to date.

Confirmation of a relationship between Developmental Dyspraxia and Sensory Responsivity could result in revision and adjustment of intervention protocols for Developmental Dyspraxia. It could also shift the focus from sensory discrimination to sensory detection and central nervous system arousal in the initial stages of intervention, thus optimising intervention strategies and possibly reducing the duration of treatment.

1.7 SCOPE AND LIMITATIONS OF THIS RESEARCH

1.7.1 Representation and Compliance

This research was intended to take place in three provinces of South Africa with the intention of attaining a degree of geographical representation. Data collection ultimately took place in two provinces due to a lack of compliance from occupational therapists recruited to the study. From the 22 initially recruited occupational therapists only 10 contributed to the study. This research study is not geographically representative of the whole of South Africa.

Compliance of parents, caregivers or teachers to complete and return questionnaires was anticipated to be a possible limitation to the study. It did not prove to be a limitation as parents and teachers faithfully returned completed questionnaires. However, the return of informed consent forms proved to be a compliance factor that turned out to be a limitation of the study. Lack of commitment and lack of time to familiarise themselves with the content of the informed consent resulted in parents or caregivers withholding informed consent.

1.7.2 Application to other Fields of Occupational Therapy

This study is applicable to the field of paediatric occupational therapy and results will be most suitable for use by occupational therapists working in paediatric occupational therapy and specialising in sensory integration therapy. It is therefore very specific in content and specifically confined to disorders of sensory integration.

1.7.3 Cultural and Economic Differences

The standardisation sample of the SIPT allows for cultural, ethnic and social differences.[21] The Sensory Profile and School Companion (SPSC) standardisation sample does not specify the cultural, ethnic or geographical compilation. According to recent studies[22-24], the SP proved to accurately measure patterns of response to sensory experiences in children from different cultures as well as present with discriminant validity in a cross-cultural context. The SPSC is a fairly new addition to the group of measurement instruments used to evaluate observable behaviours of sensory modulation. It has not been subjected to discriminant validity studies in other cultures. Subjects tested for this research study were representative of different ethnic backgrounds, but mostly from a middle class socio-economic background.

1.7.4 Language

The SIPT instructions are only available in English and Afrikaans. This results in limited access to the SIPT for South Africans who do not have a good command of English or Afrikaans. Language is therefore a limitation that makes the study sample not completely representative of all South African children age 4 years through 8 years 11 months.

1.8 LAYOUT OF THIS RESEARCH

The research contains the following chapters and annexures:

Chapter 1: Includes an introduction and background to the research study.

Chapter 2: Contains a literature review of the following constructs relevant to this research study:

- Sensory Integration

- Developmental Dyspraxia discussed from Sensory Integration Theory, Motor Learning Theory and Dynamical Systems Theory perspectives.
- Sensory Modulation Disorder and sub-patterns, namely sensory over-responsivity, sensory under-responsivity and sensory seeking, are discussed. A historical overview of Sensory Modulation Disorder is also given.
- The measurement instruments used in this research, namely the Sensory Integration and Praxis Tests (SIPT), the Sensory Profile (SP) and the Sensory Profile School Companion (SPSC), are presented and evidence of research pertaining to these instruments is also given.

Chapter 3: Provides information on the research design as well as the research methodology.

Chapter 4 : Contains the results of this research study, analysis of the results and sub-conclusions of the results in relation to the research aim and objectives.

Chapter 5: Consists of a summary of findings, conclusions, summary of contributions, and recommendations for possible future research projects ensuing from this research study.

The following annexures are included:

A: Sensory Integration and Praxis Tests

B: Sensory Profile Caregiver Questionnaire and Summary Score Sheet

C: Sensory Profile School Companion Teacher Questionnaire and Summary Score Sheet

D: Parent/Caregiver Informed Consent

E: Teacher/Principal Informed Consent

F: Cover Letter to Occupational Therapists

G: Occupational Therapist Informed Consent

H: Child Assent Form

I: Sensory Integration and Praxis Tests Computer Report

1.9 CONCLUSION

Sensory Integration as a frame of reference in the assessment and treatment of children with developmental delay has allowed the delineation of children with typical function from those with dysfunction. Sensory Integration Theory has opened doors to look at dysfunction from a neurophysiological and behavioural perspective and has allowed occupational therapists to develop and expand on Ayres' theory. These developments and expansions leave room for new questions to be asked about the relationships between patterns of Sensory Processing Disorder, such as the one posed by the researcher. Verification and exploration of the relationship between Developmental Dyspraxia and Sensory Responsivity could contribute significantly to occupational therapy literature on Sensory Integration. Many South African children with learning difficulties and developmental delays are diagnosed with Developmental Dyspraxia. Evidence through empirical research that validates a relationship between Developmental Dyspraxia and Sensory Responsivity could potentially alter treatment protocols and add value to intervention approaches and possibly reduce duration of treatment.

1.10 SUMMARY

In this chapter background to the research study and research problem was given. The aim of the study, clarification of concepts used in the study as well as possible benefits of the research study was given. Furthermore, the limitations of the study and a layout of the research were provided. Chapter 2 consists of the

literature review that gives an overview of literature and research related to the constructs of Developmental Dyspraxia and Sensory Modulation Disorder. It also describes the measurement instruments used in this research study and provides information regarding the tests' statistical soundness and validity.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter contains a literature review of the constructs pertaining to this research study. Firstly, Sensory Integration as a construct will be defined. Sensory Integration Dysfunction and the development of measurement tools to identify Sensory Integration Dysfunction will be explained. Emerging trends and the natural progression to the use of new terminology and classification of Sensory Integration Dysfunction will also be given.

Secondly, an in-depth discussion will follow about Developmental Dyspraxia, a construct related to this study. Developmental Dyspraxia will be viewed from the major frames of reference that have guided occupational therapy intervention in the past two to three decades. These frames of reference are derived from Sensory Integration Theory, Motor Learning Theory and Dynamical Systems Theory. Sensory integration and motor learning frames of reference are relevant because they uphold information processing as central. Dynamical Systems Theory is relevant because it emphasises the importance of the environment, context of the task, as well as the person in the process of task performance.

Thirdly, Sensory Modulation Dysfunction and the sub-patterns Sensory Under-responsivity (SUR) and Sensory Over-responsivity (SOR) will be discussed in terms of current views as well as research in the field. A historical overview of Sensory Modulation Dysfunction as it evolved over the past thirty years will also be given.

Lastly, the measurement instruments used in this study will be reviewed. Evidence regarding reliability, construct validity and discriminant validity will be provided. A review of literature that reports the measurement instruments' use, validity, application and appropriateness will also be given.

2.2 DISCUSSION OF CONSTRUCTS

2.2.1 Sensory Integration

2.2.1.1 A Brief Evolutionary Overview

Sensory integration is the organisation of sensory input for use, as defined by Ayres in 1972.[25] Ayres used a neurobiological model to relate human function to neurological processes, specifically central processing of information. Central processing refers to brain-stem level sensory processing that enables higher neural centres to develop and specialise.[4] When an individual's central processing of sensory information is efficient, it results in modulation and praxis as well as organised behaviour and the ability to make adaptive responses.

If processing of sensory information is disorganised, the result would be disorganised behaviour. Disorganised behaviour can result in reduced capacity to engage in everyday occupations. The term Sensory Integration Dysfunction was thus used by Ayres to describe inefficient sensory processing, specifically in children with deficits in learning. Children with sensory integrative dysfunction typically experience difficulty with academic achievement, personal identity, activities of daily living, behaviour and social participation.[4]

Through her work in linking sensory integration problems in children to patterns of dysfunction, Ayres pioneered the development of a measurement instrument for Sensory Integration, namely the Southern California Sensory Integration Test

(SCSIT), in 1972. This test led to the development of the Sensory Integration and Praxis Tests (SIPT) in 1989.[3]

Ayres[3] managed to identify a typology of Sensory Integration Dysfunction through a series of factor and cluster analysis of, initially, the SCSIT and later the SIPT. She identified six patterns of dysfunction in sensory integration from cluster analysis, which were later confirmed and refined by Mulligan in 1998, who determined the five patterns of Sensory Integration Dysfunction.

From the work of Ayres and Mulligan, theorists and researchers developed a variety of assessments of sensory processing as well as intervention protocols. The content of literature pertaining to assessment and intervention of dysfunction in sensory integration by Bundy, Lane and Murray[2], Parham and Mailloux[3], Smith Roley, Blanche and Schaaf[4], builds on the research initiated by Ayres and continued by Mulligan.

As Sensory Integration Theory evolved and an expansion of terminology in literature related to Sensory Integration took place, researchers and occupational therapists united in an attempt to provide uniformity in Sensory Integration terminology.[7,10,26] This was specifically done to provide clarification over evolving constructs and to encourage uniformity when using terminology that describes Sensory Integration Dysfunction.

This expansion of terminology associated with Sensory Integration Dysfunction resulted in these terms being used interchangeably with terminology used in diagnostic classification references in the USA.[9] A classification proposed by Miller et al in 2007 suggested changes in terminology of diagnostic categorisation of people with sensory-based processing problems. This classification proposed the use of the term Sensory Processing Disorder as an encompassing term that also reflects sensory integration.[9]

Another outcome of the classification by Miller et al (Figure 1.1) was the proposal of a categorisation of Sensory Processing Disorders that builds on the patterns of dysfunction identified by Ayres. These patterns of dysfunction are slightly modified as the categorisation is divided into three groups with lower-order sub-patterns. Two of these Sensory Processing Disorder patterns are of relevance to this study. They are Sensory Modulation Disorder and Sensory-Based Motor Disorder, of which Developmental Dyspraxia is a sub-pattern.

A discussion of Developmental Dyspraxia follows. The discussion will entail a review of the theories that underpin Developmental Dyspraxia and give an overview of research pertaining to Developmental Dyspraxia.

2.2.2 Developmental Dyspraxia

2.2.2.1 Sensory Integration and Developmental Dyspraxia

To develop an understanding of the term dyspraxia from a sensory integrative perspective, it is necessary to understand where the term stems from. The term dyspraxia originates from the word praxis. Praxis is a uniquely human skill that enables us to interact effectively with the physical world. It is one of the most critical links between brain and behaviour.[18]

The word praxis refers to the ability to formulate a concept or idea, organise pertinent information in order to formulate a plan, then sequence, time, and execute the movement, or motor plan. It involves the ability to know what to do and how to do it.[14] Praxis, as described by Ayres and in subsequent literature on Sensory Integration, consists of three basic practic processes namely: Ideation or conceptualisation, planning a scheme of action (motor planning) and motor execution.

Ideation or conceptualisation is central to praxis and involves knowing what to do.[16] It is a cognitive function and dependent, in part, on the integration of sensory inputs and resultant knowledge of possible body actions.[27]

The two practic processes that follow ideation are motor planning and motor execution. Motor planning is a consciously formulated internal plan of action that occurs before actual motor execution. To motor plan the brain must have various kinds of information. It must be able to conceptualise the action and its goal by knowing the tactile, kinaesthetic, proprioceptive and vestibular systems.[18] Motor planning is followed by motor execution, the process of performing the motor act. This is the final stage of praxis and is dependent on the initial two stages.

Ayres first referred to deficits in praxis as Developmental Apraxia, based on the insights she gained from adult apraxia literature. Apraxia is, however, associated with brain damage and Ayres subsequently replaced it with the term Developmental Dyspraxia.[3] It was through her research of patterns of Sensory Integration Dysfunction that a link was made between problematic sensory processing and impaired praxis. This discovery through cluster and factor analysis of the SIPT led to the identification of different groups of practic disorders that are related to deficient processing of sensory information.

Ayres proposed that motor planning, in particular, depended on the development of body scheme or an internal model of the body in action. This internal model began with tactile awareness, but also depended on proprioceptive sensation. Vestibular sensation from active movement is also believed to contribute to the development of body scheme.[16] The combination of tactile, proprioceptive and vestibular sensation is thus believed to play a role in specifically projected action sequences.

Four types of Developmental Dyspraxia are linked to poor sensory discrimination of either the visual, vestibular, proprioceptive or tactile systems. Murray-Slutsky[14] describes the four types of Developmental Dyspraxia as follows:

Somatodyspraxia is identified when children appear clumsy, have poor tactile discrimination, have poor body scheme, poor fine motor and gross motor skills and have oral motor problems.[14]

Bilateral integration and sequencing deficits occur when children have difficulty using the two sides of the body together in a coordinated fashion. They often fail to develop a skilled hand dominance or preference, avoid crossing the midline of the body and experience difficulty with anticipating movements. It is believed to be a disorder of praxis due to impaired processing of vestibular-proprioceptive information.[14]

Dyspraxia on verbal command is identified when children are unable to physically assume postures on verbal command. It is believed to be a dysfunction of the left hemisphere and not a sensory integrative dysfunction.[14]

Children with visiodyspraxia have poor form and space perception, visual-motor coordination and visual construction. Visiodyspraxia may be the end result of somatodyspraxia.[14]

Mulligan[28], through a confirmatory cluster and factor analysis study, refined the patterns of Sensory Integration Dysfunction originally identified by Ayres. She proposed two models of viewing patterns of dysfunction. The one model fits in with the types of dysfunction explained above. The other hypothesised model has a slightly different perspective and proposes viewing specific patterns of dysfunction as extensions of generalised practic dysfunction. Thus, instead of identifying a bilateral integration and sequencing deficit, rather view the child as

having a general pratic dysfunction with a weakness in bilateral integration and sequencing.[28]

When drawing on the work of Ayres it is possible to define Developmental Dyspraxia and to use a sensory integrative frame of reference to describe the different stages of praxis and identify the different types of dyspraxia. The development of the SCSIT and the SIPT and subsequent construct validity, factor and cluster analysis studies, provide evidence that links dyspraxia with underlying sensory processing deficits. The tactile, proprioceptive, visual, vestibular and auditory systems are specifically relevant, as deficient processing of sensory information from these systems is thought to affect praxis abilities.

2.2.2.2 Motor Learning Theory and Praxis

Motor Learning Theory gained popularity when the hierarchical view of the CNS was replaced by the view that the CNS is multilevel and multi-system.[29] The emergence of Motor Learning Theory provided therapists with the opportunity to study and view motor skill acquisition from a different perspective than Sensory Integration. Over the years there have been many contributions from researchers and theorists on the subject of motor learning. The main focus of this overview is to present the perspectives of Motor Learning Theory that apply to Developmental Dyspraxia and that are applicable to the paediatric occupational therapy domain.

According to Higgins[30], skill acquisition cannot take place effectively without considering the context in which the task or skill is acquired. Motor skill acquisition refers to learning, and learning is viewed as the process by which the person organises available resources. Motor learning thus refers to the acquisition or modification of movement.[16]

The context in which motor learning takes place is a cornerstone of occupational therapy practice, since acquiring skill should be contextual and meaningful. Subsequently, it is essential to view the individual as engaged in meaningful interaction with the environment to effect adaptive behaviour through efficient use of available resources. The link between motor skill acquisition and sensory integration is, in part, founded in the shared perspective of context-dependent intervention that elicits an adaptive response.

There are two models that dominated literature on Motor Learning and these two will be discussed briefly:

Firstly, Adams[29] proposed the concept of a closed-loop process to acquire skill. He posited that sensory feedback is required for learning a new motor skill. The feedback (referent) is used to compare movement and detect error. Learning is enhanced by repeated practice of that movement. This theory has been refuted by studies that proved that motor learning is possible without sensory feedback.[29]

Schmidt[31] is responsible for the Schema Theory or the open-loop process. This model proposed a motor programme or pre-planned sequence of actions that could be executed without feedback. The occurring movement is evaluated and modified by the movement experience. Schmidt's model gave rise to motor learning concepts, such as feedback and knowledge of results.

Motor learning principles evolved from Motor Learning Theory. These principles are phases of learning, feedback, practice and types of tasks. The first principle of motor learning, phases of learning, is delineated into three phases - the cognitive phase, the intermediate phase and the autonomous phase.

The cognitive phase, according to Fitts and Posner[29], is the phase in which a cognitive map of the movement is established. Motor learning is primarily under visual control in this phase. The second phase is the intermediate phase in which

movement patterns become coordinated. Proprioceptive feedback is thought to be important in this phase. The third phase is the autonomous phase, which translates into a motor programme with minimal conscious attention.[29]

The second principle of motor learning is feedback, which can be divided into two types of feedback, namely intrinsic feedback and extrinsic feedback. Intrinsic feedback is the feedback derived from the sensory systems and consists of two types of sensory information.[29] Sensory information that is available prior to the action is termed feed-forward or corollary discharge and includes information related to the environment and the performer with respect to the upcoming action.[32] Internal correlates of motor signals are sent to muscles after an action is planned and prior to the execution of the motor plan. Corollary discharge is deemed important for differentiating between active and passive movement, but also plays an important role in projected action sequences that are part of praxis.[33] Another type of intrinsic feedback is sensory information that is available during or after the action and relates sensations associated with the movement itself. Feedback and feed-forward is sensory information and is called intrinsic feedback or response-produced feedback.[32] Intrinsic feedback is associated with implicit learning or learning that is not under conscious control.[29]

The second type of feedback and a principle of motor learning is extrinsic feedback. Extrinsic feedback is associated with explicit learning that takes place as a result of clearly stated directions or instructions.[29] There are two types of extrinsic feedback, namely knowledge of results and knowledge of performance. Knowledge of results is augmented extrinsic information about task success and is provided to the performer. Knowledge of results and knowledge of performance are utilised in therapy settings to assist in motor skill acquisition.[34]

The frequency of the feedback, whether it is on the outcome of the movement (knowledge of results) or the components of the movement pattern (knowledge of performance), is of importance in motor learning. In children, 100% feedback is

reported to effect better motor skill acquisition, but not necessarily better retention of skill.[29]

The third motor learning principle is type of task and affects how a skill is learned. Schmidt and Lee classified a few, but the most relevant in dyspraxia would be open tasks versus closed tasks.[29] Open tasks would require feed-forward, as the environment is constantly changing. Closed tasks take place in a stable environment and would be more feedback dependent, but could require feed-forward.

Together with types of tasks, practice of tasks is of importance as a task is learnt through practice. Practice schedules that have been identified are massed practice versus distributed practice and blocked practice versus random practice.[29] In developmental dyspraxia distributed practice and random practice would best fit in with a sensory integration frame of reference. There would also be value in practicing both part and whole tasks when treating Developmental Dyspraxia. Combining distributed and random practice with practicing, firstly, parts and then whole tasks may offer a good fit with a sensory integration approach when treating children with Developmental Dyspraxia.

Lee, Swanson and Hall[35] contributed another dimension to practice of movement in motor learning. Adams first found that watching someone learn a motor skill is an effective teaching strategy. This finding was confirmed and extended by Lee and White. Their study highlighted the benefits of watching an unskilled model learn a task. Here the effect of observation in motor learning emphasises how cognitive operations sub-serve the learning of motor skills.[35]

The importance of cognitive operations highlights a very important aspect of Motor Learning Theory, namely Information Processing. Motor learning cannot take place without considering perception and cognition. Mulder[34] states that cognition, perception and action form the components of a flexible and functional

system. Information processing is of relevance in the interval between the stimulus and the actual motor movement. In Mulder's Model of Information Processing, the flow of information from the inception of a goal or intention to act, through to performing the motor act is depicted as it pertains to motor learning. This process of information processing focuses heavily on the role of sensation in feed-forward and response selection as well as feedback that takes place later in the process.[1,34]

A significant component in Mulder's Model is response selection, where Mulder debates the proposed use of a motor programme from memory to explain the flexibility of motor behaviour. He posits the concept of a programming rule that allows for novel actions to be performed without prior reference to a motor programme. The context of the task is of relevance in selecting the most adequate movement. This concept fits with Schmidt's Schema Rule. [34] It also fits with Higgins'[30] emphasis on task and context.

Higgins[30] emphasised the importance of context and task in the organisation of skilful movement (motor learning). Higgins elaborates on the process of motor skill acquisition by accentuating the significance of problem solving through task analysis and analysis of the environment during skill acquisition. The process of task analysis, problem solving and analysing the environment is dependent on feedback and cognitive processes that are supported by information processing. Problem solving results in the modification of environmental and personal constraints so that the optimal strategy to perform functional tasks can be found.[31]

In order for an individual to successfully achieve skill acquisition it is expected of him to analyse the task and the environment and to solve problems related to the movement through feedback. Effective movement is thus dependent on a coordinative relationship between the body and the environment.

It is through this coordinative relationship between body and the environment that Motor Learning Theory fits in with a contextual perspective such as Dynamical Systems Theory. Dynamical Systems Theory focuses on the interaction of the person with the environment, but builds on the ecological approach to motor learning.

Gliner[36] proposed the ecological approach to motor learning to emphasise that the environment must be considered as necessary support for coordinated skilled movement. The Ecological Model thus focuses on adaptation to the environment.[36] It allows for the actor (person) and the task to be considered. Because a task has meaning, conscious attention is paid to it and this permits the subconscious centres to integrate and organise a response.[36]

Building on the Ecological Model of Gliner, Dynamical Systems Theory encompasses aspects of both Sensory Integration Theory and Motor Learning Theory. It is a heterarchical Model that sees the nervous system as only one among many that influences motor behaviour. Open-loop and closed-loop systems work cooperatively and information processing is utilised in an attempt to achieve task goals.[31] Furthermore, it poses that a developing system chooses the most stable, comfortable or efficient pattern or solution for function, given a specific context or developmental point.[37] Thus, functional tasks and the environmental context are used to organise behaviour.[31]

Dynamical Systems Theory thus provides an over-arching model of viewing motor behaviour. It proposes that order and pattern emerge from the interaction and cooperation of many systems and that self-organisation is evident in all phenomena.[31] This fits in with Sensory Integration Theory as both theories advocate doing or acting within a meaningful context.[16]

2.2.2.3 Merging Underlying Theories

The challenge in using different frames of reference in the intervention of dyspraxia is to merge concepts related to these frames of reference in such a way that the one theory supplements the other in the areas where that theory is lacking. Merging Sensory Integration Theory with Motor Learning- and Dynamical Systems Theories provides a unique opportunity to address Developmental Dyspraxia on all levels, as it encompasses both a bottom-up and top-down approach.

A sensory integration frame of reference views deficient central sensory processing as the basis for Developmental Dyspraxia. The stages of information processing, specifically stimulus recognition and response selection, could be a good fit with the practic process of ideation, as described by Ayres. This supposition is supported by Bruner[38], who referred to ideation as “intention” and proposed that intention in children is accompanied by an increased arousal state. The Gibsons[38] advocated the role of the environment in ideation and stated that objects possess certain attributes and, in context to their environment, elicit or invite interaction. Consequently, external referents or sensory inputs can drive or generate ideas for action performance (praxis).

Ojemann[38] advocated the importance of language in ideation, a relationship strongly supported by Ayres. Ayres clinically identified children with language problems as having the greatest difficulties with ideation. Luria[38] emphasised the role of internal referents, particularly speech and language and cognitive functions, as an integral part of independent goal-directed actions. The role of internal and external referents in ideation is therefore clearly stated and examined by various investigators.

Another important component associated with ideation is that it is accompanied by an increased arousal state in order to notice internal and external referents. A

decreased arousal state could be the problem in ideation of children with sensory under-responsiveness, as they tend to under-respond to internal or external referents and therefore do not present with adequate ideation. The presence of sensory under-responsiveness in children is hypothesised by the researcher to contribute to inconsistent central nervous system arousal. This results in inadequate observation of internal and external referents and therefore impacts on ideation in praxis. This has been clinically observed during testing of children who have sensory under-responsivity with the SIPT. These children present with below average scores on the praxis on verbal command test of the SIPT and they generally struggle to follow verbal instructions due to an inability to generate a motor image (ideation) from the internal referent.

An increased arousal state could, however, also impact on praxis, specifically the processes that follow ideation. Sensory over-responsiveness is viewed as preventing people from making effective functional responses (a product of good praxis).[9] Tactile and auditory over-responsivity are the most common domains of sensory over-responsivity and are reported to affect the ability to perform everyday activities.[39] In the praxis process, motor skill acquisition is an important aspect of motor learning. Singer[40] emphasises the importance of the maintenance of optimal arousal during motor learning. A state of increased arousal due to sensory over-responsiveness may, therefore, impact on the ability of a child with developmental dyspraxia to allocate attention and use feedback appropriately during motor learning.

The role of the Information Processing Model of Motor Learning, developed by Schmidt and elaborated on by Light and Mulder[1], is relevant in the development of praxis and is, in principle, similar to the three processes of praxis (ideation, motor planning and execution) described by Ayres in her work. Information processing forms the basis for movement learning that consists of open-loop and closed-loop control systems. According to Schmidt[1], movement learning is dependent on visual, kinaesthetic and vestibular/proprioceptive input, and the

feedback from these sensory systems contributes to effective motor performance of actions through a feedback-dependent action (closed-loop system) or a feed-forward control open-loop system.

The practic processes of motor planning and motor execution are dependent on adequate processing of the tactile, vestibular and proprioceptive information. The motor planning process involves either feedback and/or feed-forward, depending on the complexity and the demands of the action. Motor execution makes use of either feedback or feed-forward. Motor learning is therefore an integral part of praxis and is relevant in the last two practic processes. Several studies[1] investigating information processing and motor control focused on the visual and proprioceptive systems and included research on perceptual-motor function, visual-spatial processing, visual feedback and kinaesthesia to identify the relationship between clumsiness (part of the clinical picture of dyspraxia) and sensory processing. Findings of these studies were inconclusive and emphasise the need for further studies to examine the relationship between sensory processing and motor coordination.[1]

The subtle interplay between sensory and motor systems was also highlighted in a review of literature by Cermack and Goodgold-Edwards in 1990.[40] The integration of motor control and motor learning concepts with neurophysiological perspectives on apraxia and developmental dyspraxia fits in with the practic processes of praxis described by Ayres. Willoughby and Polatajko[41], in a literature review in 1995, outlined motor problems in dyspraxia. Their review emphasised the connection between motor performance and sensory processing by linking motor control and motor learning to Sensory Integration Theory. The link between motor performance and sensory processing is thus suggested, but does not suggest a link with the modulation aspect of sensory processing.

When reviewing Developmental Dyspraxia as a construct it is not possible to view it from one perspective. Sensory Integration Theory enabled Ayres to define

and describe Developmental Dyspraxia in specific detail. It also assisted in linking patterns of dysfunction to deficiency in sensory processing, but specifically emphasised the relationship between the tactile system and praxis. Motor Learning Theory and Dynamical Systems Theory link with Sensory Integration Theory on many levels. On one level the link between information processing in skill acquisition and ideation is clear. On another level is the shared view of the central nervous system as heterarchical.[42] On a third level is the corresponding view that doing or acting should be meaningful and contextual. Considering all the shared components, the three theories, as they pertain to Developmental Dyspraxia, provide an encompassing perspective of this dysfunction.

2.2.3 Sensory Modulation Dysfunction

2.2.3.1 Current Perspectives on Sensory Modulation

Sensory modulation is the ability to regulate and manage one's responses to sensory input in a graded and adaptive manner.[43] When an individual over-responds, under-responds or fluctuates in response to sensory input in a manner disproportional to that input, it is said that the individual has a Sensory Modulation Dysfunction.[7] The term Sensory Modulation Dysfunction is used interchangeably with Sensory Modulation Disorder in this literature review, as explained in Section 1.5.

Sensory Modulation Dysfunction can refer to either physiological reactions or behavioural responses. On a behavioural level it refers to a person's inability to organise and regulate responses to sensations in a graded manner that corresponds to the situational demands.[20] Physiologically it refers to inadequate mechanisms of sensitisation and habituation that alter the structure of nerve cells.[20]

The neurophysiological process of modulation involves neuronal activity that is enhanced or dampened in response to various sources of input to meet current demands. There is both peripheral and CNS involvement, where sensory receptor cells become more or less responsive to input.[6] Sensory signals are transduced to electrical and chemical energy to be converted into an electrical signal. The electrical signal is sent when the stimulus strength of the signal reaches a threshold and an action potential is produced. The electrical signal changes to a chemical signal at the point of interaction between the neurons. To fire an action potential, stimulus intensity must reach threshold level. This process of transduction involves transforming environmental sensory input to an electrical signal.[10]

When the electrical signal changes to a chemical signal the neurotransmitters help to carry the signal between the incoming axon and the point of contact.[10] The signal interacts with receptors and, if the input is of sufficient intensity, the receptor will fire and generate neuronal signals. Thus, modulation at cellular level comes from activation of specific inputs to a cell. Increasing excitatory inputs result in postsynaptic firing and sending information forward, whereas increased inhibitory inputs will block further transmission of the impulse.[6]

Behavioural manifestations of sensory modulation, and specifically sensory responsiveness, have been assessed through the use of survey instruments. These measurement instruments use self- or parent report to identify the frequency of behaviours in response to sensory stimuli. Behavioural manifestations of Sensory Modulation Disorder include over-responding, under-responding or fluctuating response to sensory input. [44]

Miller et al proposed a classification consisting of sub-patterns of Sensory Modulation Disorder, namely sensory over-responsiveness, sensory under-responsiveness and sensation seeking. These sub-patterns are briefly explained.

Sub-pattern 1 – Sensory Over-responsivity (SOR)

People with SOR respond to sensation faster, with more intensity, or for a longer duration than those with typical sensory responsivity. Over-responsivity may occur in only one sensory system or in multiple sensory systems. Behaviours in SOR range from active, negative, impulsive, or aggressive responses to more passive withdrawal or avoidance of sensation. Sympathetic nervous system activation is a marker of SOR, which may result in exaggerated fight, flight or freeze responses.[9]

Sub-pattern 2- Sensory Under-responsivity (SUR)

People with SUR have a tendency to respond less to sensory stimuli in their environments. They appear not to detect incoming sensory information. This lack of initial awareness may lead to apathy, lethargy and a seeming lack of inner drive to initiate socialisation and exploration. SUR occurring in the tactile and proprioceptive systems usually leads to poor tactile discrimination and a poor body scheme with clumsiness.[9]

Sub-pattern 3 - Sensory Seeking (SS)

People with sensory seeking crave an unusual amount of sensory input and seem to have an insatiable desire for sensation. They energetically engage in actions that add more intense sensations to their bodies in many modalities. Invasive SS behaviours can influence social interactions with peers while active SS often leads to socially unacceptable behaviour, including constant moving, crashing and bashing, bumping and jumping, impulsiveness, carelessness and restlessness.[9]

Sensory seeking as a sub-pattern has been questioned by Liss et al[44], since seeking behaviours have been found in populations exhibiting both over- and under-responsiveness. It has been suggested that sensory seeking is more a compensatory mechanism used to moderate high arousal levels. For the purpose of this study and to fit in with Dunn's Model of Sensory Modulation Dysfunction

used in this study, sensory seeking behaviour will be grouped with SUR and not viewed as a separate sub-pattern.

Building on the sub-patterns of Sensory Modulation Disorder, Murray-Slutzsky[19] identified three phases of sensory modulation: registration, orientation and arousal. Sensory registration asks the question "What is it?". According to Murray-Slutzsky, when registration occurs there is a phasic physiological response or arousal to the input that occurs.[19]

Orientation to the stimulus occurs next. After sensory information is registered, the child will orient to it, evaluating its significance. An involuntary tonic physiological readiness to respond occurs. It causes us to ask, "What is to be done?" The final phase, arousal, is preparation for action, the exertion of effort or attention. This is now a voluntary mechanism in which effort and energy must be expended.[19]

The term sensory registration, when used in literature that describes and defines sensory modulation, is under contention as it is used to describe the behaviour of noticing sensory stimuli in the environment. Miller, Lane and Haft[10] proposed the use of the term sensory detection, as it is more consistent with neurophysiological literature and reflects CNS activity in response to sensory input. For the purpose of this study, sensory detection would thus be an applicable term to use.

2.2.3.2 A Historical Overview of Sensory Modulation Dysfunction

The construct of Sensory Modulation has evolved over time and, along with research conducted in the area of sensory modulation, several researchers and theorists have put forward different models to explain and expand on the initial model of sensory modulation. To form an understanding of the current trends and

models used to describe and classify Sensory Modulation Dysfunction, it is imperative to review the history of Sensory Modulation Dysfunction.

Ayres was the pioneer of Sensory Integration Theory and her initial perspectives on sensory modulation emphasised the concept that the brain has the ability to regulate its own activity. She introduced the concept of tactile defensiveness and also suggested that hypersensitivities may occur in other sensory modalities.[45]

Building on Ayres' initial conceptualisations, Knickerbocker[45], in 1980, expanded the concept of tactile defensiveness to a broader category of sensory defensiveness. She placed sensory defensiveness on a continuum with sensory dormancy. According to her, sensory dormancy was due to too much inhibition and sensory defensiveness due to too little inhibition. Supplementary to Knickerbocker's model, Dunn and Fisher[45] proposed a model that placed tactile defensiveness and registration on opposing ends of a single continuum.

Cermak's[45] contribution was in the form of a review on different perspectives of arousal and attention from outside the field of occupational therapy. Her review covered the work of Kinsbourne, Zentall and Porges and highlighted linear conceptualisations that were simple, but did not reflect the complexity of neural function. Following Cermak's contribution, Fisher, Murray and Bundy expanded Ayres' conceptualisations and included aversive responses, gravitational insecurity, sensory defensiveness and tactile defensiveness. They further listed avoidance, distraction and increased activity level as products of sensory modulation dysfunction.[45]

Lane and Royeen[45] proposed a circular model of Sensory Modulation Dysfunction with over-orientation and failure to orient at the opposing ends, but with sensory dormancy and sensory defensiveness potentially being adjacent functions due to the design of the model. Koomar and Bundy's[45] work focused on describing a complex condition where an individual could have problems with

both modulation and discrimination. Their additional contribution was providing an overview of treatment approaches for modulation difficulties.

Further contributions to sensory modulation dysfunction include the work of Wilbarger, which proposed that sensory defensiveness is one of a subset of sensory modulation disruptions. Kimball's model was based on arousal states that she proposed fluctuated within a range of normal, where performance and adaptive capacity are poor at both high and low levels of arousal. She also introduced the concept of "shutdown". Parham and Mailloux supported the views of Cermack and Royeen, where modulation disorders are represented on a continuum from registration problems to sensory defensiveness.[45]

A more recent contribution to Sensory Modulation Dysfunction is that by Dunn, who developed a model where individuals are classified by their neurological threshold and behavioural responses to incoming stimuli. According to Dunn's model, high neuronal thresholds are indicative of a nervous system that requires more intense input to elicit a behavioural response and is suggestive of an under-responsive system. A lower neuronal threshold is indicative of a nervous system that requires less intense stimulation to fire and is suggestive of an over-responsive nervous system.[44] Based on this model, Dunn developed a measurement tool to assess sensory modulation. This measurement tool (Sensory Profile) has been used in many research studies to investigate sensory modulation in children from various diagnostic populations.

Another recent model of Sensory Modulation is the Ecological Model of Sensory Modulation (EMSM), where external contextual factors that interact with internal factors creating Sensory Modulation Dysfunction are highlighted. The EMSM, therefore, embodies the belief that behaviour of individuals with sensory modulation dysfunction can only be understood within the context of their external life. The four external dimensions of the EMSM are culture, environment, relationships and task and the three internal dimensions are attention, emotion

and sensation.[20] The EMSM fits with Dynamical Systems Theory as both consider the effect of environmental and external constraints on the ability to produce adaptive responses.

2.2.3.3 Pulling it all Together

Sensory Modulation Dysfunction as a field within Sensory Integration has been the subject of many research studies, with ongoing research taking place to gain insight into the neurophysiological and behavioural components of this dysfunction. For the purpose of this study the focus will be on the initial phase of sensory modulation, namely sensory detection.

An individual that functions at the under-responsive end of the continuum may be said to have diminished sensory detection. This person fails to notice sensory stimuli that elicit the attention of most people. On the other end of the sensory responsivity continuum is over-responsivity, where a person notices sensory stimuli more readily and is easily distracted by movements, sounds, smells and everyday sensations.[46] A sensory detection problem, whether it is detecting too much or too little, interferes with the child's ability to attach meaning to an activity or situation. The long-term effects of inefficient sensory detection on the child's development can be profound. [3]

The combination of the views on Developmental Dyspraxia with perspectives on Sensory Modulation Dysfunction, while considering the processes that underpin these two patterns of Sensory Integration Dysfunction, led to the research problem and problem statement stated in Chapter 1. The concept of praxis, where the importance of sensory detection in ideation is emphasised by Murray–Slutsky[19], may be the foundation for a link between Developmental Dyspraxia and Sensory Modulation Dysfunction. Children with sensory under-responsivity have diminished or poor sensory detection. The existence of a relationship between Developmental Dyspraxia and sensory under-responsivity will thus

impact on ideation in praxis due to decreased sensory registration and not enough arousal to notice internal and external referents. Whereas children with sensory over-responsivity will have the tendency to register sensory information more frequently and with greater intensity (which results in over-arousal and inattention), that, in turn, could impact on the motor acquisition phase of motor learning. Motor planning and motor execution are implicated because detection precedes sensory discrimination and sensory discrimination is of importance in the development of body scheme, which contributes to the ability to formulate a motor plan and subsequently execute the motor plan.

2.3 MEASUREMENT INSTRUMENTS

The measurement instruments that were used in this research study are:

- The Sensory Integration and Praxis Tests (SIPT)
- The Sensory Profile Caregiver Questionnaire (SP)
- The Sensory Profile School Companion (SPSC)

These measurement instruments are discussed in terms of their intended use, scoring and interpretation, standardisation, validity and reliability,

2.3.1 Sensory Integration and Praxis Tests

2.3.1.1 Description, Validity and Reliability

The Sensory Integration and Praxis Tests (SIPT) (Annexure A) was developed as a measurement of Sensory Integration by Ayres in 1989 and is used internationally by occupational therapists qualified in the administration and interpretation of the SIPT.

The SIPT contributes to the clinical understanding of children with irregularities in learning or behaviour. These tests were designed to assess several different

practic abilities, various aspects of the sensory processing status of the vestibular, proprioceptive, kinaesthetic, tactile, and visual systems, and the major behavioural manifestations of deficits in integration of sensory inputs from these systems. Based upon the assumption that both learning and behaviour are functions of the brain, the SIPT uses a neurobiological model to help define the bases for learning or behavioural disorders.[47]

The SIPT consists of 17 tests which are divided into four groups that are not mutually exclusive:

The Form and Space Perception Tests

The form and space perception tests include: Space Visualisation (SV), Figure Ground Perception (FG), Manual Form Perception (MFP) and Motor Accuracy (MAc).

The Somatic and Vestibular Sensory Processing Tests

The term somatosensory refers to the sensory input to the brain from the body. The somatosensory (tactile and proprioception) tests assess (a) muscle and joint sense (Kinaesthesia [KIN]), (b) the perception of the spatial and temporal qualities of a series of tactile inputs (Graphestesia), (c) the ability to differentiate fingers from tactile stimuli only (Finger Identification), and (d) the ability to localise single tactile stimuli (Localisation of Tactile Stimuli [LTS]). Vestibular processing is assessed by the Post-rotary Nystagmus (PRN) test. Both somatic and vestibular processing are assessed by Standing and Walking Balance.[47]

The Praxis Tests

Practic skill is appraised in six behavioural domains. The praxis tests assess (a) the child's ability to translate verbal commands into practic acts (Praxis on Verbal Command), (b) skill in three dimensional construction (Constructional Praxis); (c) competency in perceiving, remembering and executing a series of hand and finger movements (Sequencing Praxis); (d) ability to imitate movements and

positions of the tongue, lips and jaw (Oral Praxis); (e) facility in assuming different and unusual body postures (Postural Praxis); and (f) accuracy and approach in copying designs (Design Copying). Both Design Copying and Constructional Praxis assess visio-construction skill.[47]

Bilateral Integration and Sequencing Tests

Five of the SIPT tests assess, as a group, the bilateral integration and sequencing function. These tests are Bilateral Motor Coordination and previously described Oral Praxis, Graphestesia, Sequencing Praxis and Standing and Walking Balance.[47]

The SIPT was designed for use with children 4 years through 8 years 11 months of age. The interpretation of SIPT scores requires some theoretical understanding of sensory integration and praxis, and the administration of the SIPT requires considerable skill and practice on the part of the examiner. All tests are individually administered and it is recommended that the battery be used in its entirety. The completed protocol sheets are then scored by means of computer scoring and a tests report is subsequently generated.[47]

The SIPT normative sample consisted of 1 997 children. The normative sample was selected to be as representative as possible of the population in the USA. To insure national representation the following factors were considered for the sampling plan: Age group (ages 4 years to 8 years 11 months), sex (equal numbers of boys and girls), ethnicity (five categories were used, namely: Asian, white, black, Hispanic and other ethnic groups), type of community, and geographic location. The composition of the normative sample allows for cultural differences to ensure that the SIPT is a reliable measurement instrument to use in this study.[21]

Validity of the SIPT, especially construct validity and criterion-related validity, is important not only to verify that the SIPT measures the relevant theoretical

constructs, but is also reliable to predict future performance based on current performance on tests. Construct-related evidence evolved from factor analysis of, initially, the SCSIT (predecessor to the SIPT) and later the SIPT results. The factor analysis of the SIPT (1989) revealed five factors and a confirmatory factor analysis performed by Mulligan (1998) revealed four factors with a second order factor. Mulligan's study also assisted in clarifying the SIPT major patterns of sensory integrative dysfunction.[48]

Cluster analysis assists in grouping together clinically important groups of individuals. In other words, cluster analysis is used to determine typologies from observed data to identify similar groups. Ward's method of cluster analysis was used with the SIPT data and the six-cluster solution was determined to be the most appropriate. The empirical clustering results were combined with the clinical experience of the author in order to develop the six SIPT types: Group 1: Low-Average Bilateral Integration and Sequencing (BIS); Group 2: Generalised Sensory Integrative Dysfunction; Group 3: Visio- and Somatodyspraxia; Group 4: Low-Average Sensory Integration and Praxis; Group 5: Dyspraxia on Verbal Command; Group 6: High-Average Sensory Integration and Praxis. Three of these six groups represent Sensory Integrative Dysfunction.[48]

The SIPT groups which represent dysfunction and are of relevance to this study are: Group 1: Low Average Bilateral Integration and Sequencing; Group 2 Generalised Sensory Integrative (SI) Dysfunction; Group 3: Visio- and Somatodyspraxia; Group 5: Dyspraxia on Verbal Command. The order of the groups listed above is according to the SIPT manual and not according to the SIPT groups listed in the results section (chapter 4) of this report. The reason for selecting these specific groups will subsequently be discussed.

SIPT Group 1 is listed as Low Average Bilateral Integration and Sequencing which does not necessarily reflect dysfunction, but the researcher selected this group to indicate a practic dysfunction when the SIPT scores of a subject were in

the deficient range on the following SIPT tests: Graphestesia (GRA), Oral Praxis (OPr), Sequencing Praxis (SPr), Bilateral Motor Coordination (BMC) and Standing Walking Balance (SWB). These scores were in contrast to the rest of the SIPT test scores which were not necessarily in the deficient range.[81] A BIS deficit is a relatively mild form of practic dysfunction and is generally subtle. It entails poorly coordinated use of the two sides of the body, difficulty in performing movement sequences and is proposed to reflect deficient vestibular proprioceptive processing.[16] Functional implications of a BIS deficit entail difficulty with self care tasks such as tying shoelaces, using a knife and fork in a skilled manner, cutting with scissors or riding a bicycle.

SIPT group 2 namely Generalised SI Dysfunction was selected for the research study because children whose profiles are likened to this group normally perform poorly on most of the SIPT tests.[77] Children present with generally poor functional output in their daily occupational performance and display deficient praxis in many areas of life. There may be no distinctive or identifiable pattern visible and these children may present with a combination of dyspraxia on verbal command, visio- and somatodyspraxia and a BIS deficit that present as a generalised practic disorder. Clinically it has been observed that children with this type of practic dysfunction tend to struggle more in all spheres of their occupational performance and their dysfunction may be severe.

The third SIPT group is visio- and somatodyspraxia and is associated with scores in the deficient range on Design Copying, Standing Walking Balance, Sequencing Praxis, Kinaesthesia, Bilateral Motor Coordination, Graphesthesia, Finger Identification, Postural Praxis and Motor Accuracy. [77] This type of Dyspraxia is characterised by poor planning of anticipatory, feed-forward dependant actions that depend on sensory feedback. On a functional level children with this type of practic dysfunction have delays in acquiring self-care skills, have poor organisation, difficulty assembling and manipulating toys and strained relationships with peers or siblings.[16] SIPT group 3 is linked to poor

somatosensory processing as well as poor performance on some measures of vestibular proprioceptive processing.

SIPT group 5 is Dyspraxia on verbal command and was selected for this research study based on clinical observations in practice. This practic dysfunction is most discrete and least variable in the way it manifests among children. A prominent feature of this SIPT group is the contrast in scores between Praxis on Verbal Command which is very low and a higher PRN score. Moderately low scores on Design Copying, Oral Praxis, Sequencing Praxis, Bilateral Motor Coordination and Standing Walking Balance are also associated with Dyspraxia on Verbal Command. A borderline score on the Postural Praxis test was also associated with Dyspraxia on Verbal Command due to the probability of impaired linguistic skills.[77] In the clinical setting the Researcher observed that children with this type of practic dysfunction often presented with sensory under-responsiveness and appeared slow to detect auditory sensory input. This resulted in the Researcher questioning whether these children presented with poor auditory detection as opposed to poor auditory processing.

Although the Researcher used the SIPT diagnostic clusters which groups the child's SIPT scores and likens the child's profile to a SIPT group to identify the different types of dysfunction, partial and meaningful score patterns were also considered when drawing a conclusion about a child's type of practic dysfunction. This interpretation provided the Researcher with greater flexibility in interpretation and provided more depth in detecting dysfunctions.

The SIPT furthermore has individual test validity and showed significant ability ($p<0.01$) to discriminate between normal and dysfunctional children. Test-retest reliability of the SIPT was evaluated in a sample of 41 dysfunctional children and 10 normal children and test-retest reliability coefficients range from 0.48 to 0.93. The praxis tests had the highest test-retest reliability and four tests showed low test-retest reliability (PRN, KIN, LTS and FG). Inter-rater reliability of the SIPT

was evaluated by administering the SIPT on 63 children with eight participating examiners. All inter-rater reliability coefficients for the major SIPT scores were very high, ranging from 0.94 to 0.99.[48]

2.3.1.2 The SIPT and Research

A number of studies of the SIPT were conducted in the early to middle nineties after the SIPT was first published. The studies aimed at verifying validity, examining relationships among constructs tested with the SIPT and examining applicability of the SIPT to different populations. The studies of importance aimed at confirming construct validity and reliability of the SIPT. The following studies assisted in the confirmation of the SIPT as a sound measure of Sensory Integration based on the strength of design, development and statistical properties.

A study by Lai, Fisher, Magalhaes and Bundy[49] in 1995, which examined construct validity of the praxis tests of the SIPT, determined that the five SIPT used in the study have reasonable qualities for measuring what they intend to measure. In this study only five praxis tests were used to examine construct validity as the researchers attempted to prove that bilateral integration and somatodyspraxia is a unitary function. The results from the study confirmed this hypothesis based on the use of only five of the SIPT. Their results indicated a need for further research to verify their hypothesis that children with somtatodyspraxia are affected more severely than children with bilateral and sequencing deficits.[49]

Mulligan[28] performed confirmatory factor analysis on the SIPT in 1998 to determine a plausible model for understanding Sensory Integration Dysfunction. Her study produced results that identified two possible models for viewing patterns of dysfunction. The first model is a higher order model that involved a general factor, practic dysfunction and four first order factors. The second model

is a second-order, four factor model that supports a relationship between tactile processing and praxis. This relationship is however explained by the presence of a generalised practic dysfunction. Mulligan's study also revealed that PRN, KIN, SWB and MAc have limited value in identifying strengths or weakness in sensory integration functions. The SIPT tests KIN, PRN and FG had the weakest test-retest reliability. The study supported Ayres' idea that Sensory Integration Dysfunction is a multi-dimensional construct. Interpretation of results led to the conclusion that it appears more accurate to view specific patterns of dysfunction as extensions of generalised practic dysfunction.[28]

Additional cluster analysis performed on the SIPT by Mulligan[50] in 2000 revealed a five- rather than six cluster solution with many similarities with the groups originally identified by Ayres. The groups that Mulligan identified in her study were Low-Average BIS, Generalised Sensory Integrative Dysfunction, Average Sensory Integration and Praxis (a merger between the high average and low average sensory integration and praxis clusters identified by Ayres), Dyspraxia on Verbal Command and a cluster she termed Dyspraxia. The dyspraxia cluster did not seem to fit the SIPT profiles identified by Ayres and it did not support either a visio-praxis component or a somato-sensory basis for dyspraxia. The results of this study thus displayed some overlap with the clusters identified previously, but also highlighted some differences that necessitate caution when assessing sensory integration function. Mulligan states that assessment with the SIPT should be accompanied by clinical observations and measures assessing sensory modulation.[50]

Asher, Parham and Knox[51] examined inter-rater reliability of score interpretation on the SIPT. Their study aimed at providing inter-rater reliability data for the interpretation of the entire group of SIPT. This was achieved by the rating of SIPT scores of two complex cases by a group of 20 trained therapists. Each case was rated for presence of sensory integrative dysfunction and for relevance of specific patterns of dysfunction. Comments were provided to justify ratings.

Results of this study indicated that trained clinicians can reliably draw conclusions regarding the presence of Sensory Integration Dysfunction using SIPT score profiles only. Reliability was less consistent with respect to particular dysfunctional patterns of SIPT scores. This study also pointed out that computer generated clusters should be de-emphasised in determining patterns of dysfunction. Additional clinical information should be considered in drawing a conclusion regarding a pattern of dysfunction.[51]

Kimball[52] performed a pilot study using the SIPT to measure change following occupational therapy treatment. Boys with Learning Disabilities were given occupational therapy with sensory integrative techniques. The results showed positive changes in the individual chromagraphs of most of the children and a positive effect in scores of one test of the SIPT battery. The conclusion was that the SIPT may be more sensitive to changes than the SCSIT due to the more discreet nature of the 17 tests. However, this study was preliminary and it indicated that the SIPT was more useful than the SCSIT in measurement of occupational therapy effectiveness.

Other research that examined sensory integration in different populations and the ability of the SIPT to discriminate these populations includes research in the Attention Deficit and Hyperactivity Disorder (ADHD) populations and a study conducted in the UK. Some of the results did not provide comprehensive support for hypotheses. One of these studies was conducted by Mulligan[53] in 1996 to identify and describe score patterns of children with ADHD. Her findings were that there were no significant differences in SIPT profile groups of children with ADHD and those without. The SIPT test that best discriminated the ADHD group from the group without ADHD was space visualisation and in clinical practice it would be difficult to distinguish children with ADHD from those without on the basis of their SIPT scores.

In a British study conducted by Chu[54] on a group of mainstream school children to explore the patterns and nature of Sensory Integration Dysfunction, the results indicated the presence of sensory integrative dysfunction in the experimental group. However, more than half of the experimental group was not likened to the SIPT cluster groups. The study therefore did not reveal clear patterns of Sensory Integration Dysfunction despite indications of the presence of dysfunction.

A more recent study in the application of the SIPT in a specific population is that of Lin[55] where the SIPT was used to examine the relation between Sensory Integration in children adopted from Eastern Europe and the length of institutionalisation. Results demonstrated the ability of the SIPT to discriminate between two groups of subjects (longer-institutionalised [LIH] and shorter-institutionalised [SIH]). Scores for the LIH group indicated a lower score on the SIPT as compared to the SIH, which in turn supported the hypothesis of the researchers.

Due to the fact that the SIPT was designed to be used in its entirety or only parts of the test, some studies were performed to examine relations among tests or validity of certain groups of tests. Cermak[56] compared two different ways of presenting the praxis on verbal command test (PrVc) to children. The results indicated that children aged four years performed more poorly than six-year old children on the PrVc test when instructions were presented verbally (as the test is intended to be presented). Children aged four years and six years performed better under condition of imitation. The study demonstrated the differential effects of mode of elicitation and that this factor should be considered during assessment and treatment.[56]

The space and form perception tests of the SIPT were also investigated by Cermack[57], Murray[58] and McAtee[59]. Cermak[57] provided support through her study for the validity of the Design Copying (DC) and Constructional Praxis (CPr) Test as measures of constructional abilities in children with Learning Disabilities.

Murray[58] investigated the relationship between form and space perception, constructional abilities and clumsiness in children. Her study confirmed that learning disabled children perform more poorly on four of the six SIPT tests that measure space and form perception and constructional abilities. It was furthermore established that non-clumsy children performed more poorly on two of the six tests, namely MAc and DC. The overall conclusion was that some perceptual tests of the SIPT discriminate between clumsy and non-clumsy children and that the spatial aspects of perceptual tests are more important than form perception.

McAtee's study confirmed a relationship between atypical parameters of the DC test of the SIPT and DC of the SCSIT (predecessor of the SIPT) as well as a moderate relationship between one atypical approach parameter with another of the DC (SIPT). This thus suggests that not any of the parameters were measuring the same trait.

When reviewing the research conducted with the SIPT there is evidence that supports the statistical integrity of the SIPT and confirms validity and reliability. This sufficient evidence offers support for the use of such a measurement instrument in the research study undertaken by the researcher.

On the other hand there is also evidence of mixed results or outcomes from research studies conducted with the SIPT to discriminate populations, or in correlational studies with other measurement instruments. These results warrant caution when selecting a study design and the measurement instruments used in conjunction with the SIPT. It also necessitates and in-depth understanding of the constructs measured by these tools.

2.3.2 Sensory Profile

2.3.2.1 Description, Validity and Reliability

The Sensory Profile (SP) (Annexure B) consists of 125 items. It is a judgement-based caregiver questionnaire. Each item describes the child's responses to various sensory experiences. The caregiver who has daily contact with the child completes the questionnaire by reporting the frequency with which these behaviours occur (always, frequently, occasionally, seldom or never). The therapist then scores the responses on the questionnaire. Certain patterns of performance on the Sensory Profile are indicative of difficulties with sensory processing and performance.[60]

The Sensory Profile is a tool for linking performance strengths and barriers with the child's sensory processing patterns. Its purpose is to evaluate the possible contribution of sensory processing to the child's daily performance patterns. It also provides information about both the child's tendencies to respond to stimuli and which sensory systems are likely to be contributing to or creating barriers to functional performance.[60]

Items on the SP questionnaire unite to form nine meaningful groups or factors and the 125 items of the questionnaire are grouped into three main sections: sensory processing, modulation, and behavioural and emotional responses.[60]

The scoring process of the Sensory Profile allows for the child's behavioural response to be related to their neurological threshold. There are four quadrants that describe the child's neurological threshold and their related behaviours and these are Low Registration, Sensation Seeking, Sensory Sensitivity, and Sensation Avoiding. The child's score will either be much less than most people, similar to most people, more than most people or much more than most people in each quadrant.[60]

The nine factors that were identified from a factor analytical study on a sample of children without disabilities are sensory seeking, emotionally reactive, low endurance/tone, oral sensory sensitivity, inattention/distractibility, poor registration, sensory sensitivity, sedentary, and fine motor/perceptual. The factor analysis identified the relationships among similarly performing items, and factor loadings did not sort out by sensory systems, but rather by the child's responsivity to sensory experiences. It emphasises the importance of not only considering which sensory systems are affected, but also how people respond to stimuli.[61]

Reliability of the Sensory Profile was estimated using internal consistency. Cronbach's Alpha was calculated to measure internal consistency for each section. The values of alpha ranged from 0.47 to 0.91.[62] Content validity of the Sensory Profile was achieved through a) literature review, b) expert review and c) category analysis. Construct validity of the Sensory Profile was examined through examining convergent and discriminant validity by comparing various scores of the SP with different functional tasks on the School Function Assessment.[62]

2.3.2.2 Sensory Profile and Research

Dunn conducted several studies on the SP to evaluate construct as well as content validity and performed factor analysis on samples of children with and without disabilities. From the factor analysis it was concurred that the SP contains items and factors that discriminate between children with and without disabilities, but also discriminate groups of children with disabilities from each other, thus confirming discriminant validity.[63] Clinical interpretation of factor analysis of the SP highlights the ability of the test to identify a child's sensory reactivity factors, his activity level, attention span and approach to a new activity. These responses undergird his or her ability to cope in different environments.[42]

Neuman conducted a study[23] to examine the extent to which the patterns of response of a sample of typical Israeli children were similar to a national sample of typical American children as well as verifying application of the SP scoring system to Israeli children. Findings from the study provided initial support for clinical use of the scoring system of the SP in Israel as patterns of response of Israeli children were quite similar to American children. Results confirmed that Israeli children do not differ substantially from American children in their responses to sensory experiences encountered in daily life.

Brown, Leo and Austin[22] conducted a study in Australia with the aim to evaluate discriminant validity of the SP by comparing SP scores of Australian children with a diagnosis of autism spectrum disorder (ASD) to children with typical development. The results of the study indicated that children with ASD had lower scores on all fourteen categories, on eight out of nine factors and all four quadrants of the SP. It supported discriminant validity evidence that the SP can be used with confidence in cross-cultural setting such as Australia.

The SP was also used with different diagnostic groups to determine if sensory-based behaviours of typical children differ significantly from those with specific diagnosis. Diagnoses included ASD, Fragile X Syndrome, Gifted children, Childhood Apraxia of Speech, and ADHD. A study was conducted by Dunn and Bennett[64] to compare sensory responses of children with ADHD and children without disabilities on the SP. Children with ADHD differed significantly from children without disabilities in their sensory responsiveness. The results also indicated that items of the SP may be considered additional confirmatory data in the diagnostic process of ADHD as some of the significant items on the SP are consistent with diagnostic criteria in the DSM-IV. Thus, the SP may be a useful tool for confirming central features of the diagnosis of ADHD.
A subsequent study by Yochman, Parush and Ornoy[65] in 2004 confirmed the results of Dunn's study as their results indicated that the scores of the ADHD group were significantly lower on six out of nine factors. The same applied to

comparisons between section scores where the ADHD group scored lower on 11 out of 14 sections. Children with ADHD present with significantly different patterns of sensory processing compared to typical children and are thus increasingly at risk for deficits in sensory processing.

A Study by Watling, Deitz and White[66] to examine sensory processing in children with autism revealed that SP scores of children with autism were significantly different from children without autism. Scores of eight out of nine SP factor scores were significantly lower than scores of children without autism. Differences were significant in behaviours related to sensory registration, sensory sensitivity, sensory seeking, emotional reactivity, oral sensitivity and distractibility. The findings of this study support the use of the SP to identify the sensory processing tendencies of children with autism.

Dunn, Myles and Orr[67] investigated sensory processing issues associated with Asperger syndrome in 2002. Preliminary results from the study indicated that children with Asperger syndrome consistently have lower scores than typical children. Examination of scores revealed difficulty with factors associated with hypo-responsiveness and hyper-responsiveness, suggesting that these children may have poor modulation rather than one-way responding.

Gere, Capps, Mitchell and Grubbs[68] examined the sensory processing abilities of Gifted children through use of the SP. They also wanted to compare the internal consistency of SP sections and factors for Gifted children with SP norms. Their findings showed that the SP's item and factor structure is valid for Gifted children, which also adds to the SP's validity. Results furthermore confirmed the hypothesis that Gifted children are more sensitive to their physical environment.

Another population that came under the spotlight is children with cochlear implants. Bharadwaj[69] conducted a study to examine the sensory processing abilities of children with cochlear implants. In this study it was established that

70% of the children with cochlear implants had some degree of Sensory Processing Disorder. Atypical behaviours were revealed in all domains, but were most prevalent in auditory and vestibular processing followed by oral and tactile processing.

Newmeyer et al[70] conducted a study to review and compare the results of the SP in children with Childhood Apraxia of Speech (CAS). They also aimed at exploring the relationship between Sensory Processing and sound-production deficits. Their measurement instruments included the SP, the Preschool Language Scale, the Kaufman Speech Praxis Test for Children (KSPT) and the Peabody Developmental Motor Scales (PDMS-2). Results of the study indicated differences in sensory processing when compared to same-age peers. Differences were identified in five SP factor scores, namely sensory seeking, emotionally reactive, oral sensory sensitivity, inattention/distractibility, and fine motor/perceptual. A positive correlation also emerged between the SP quadrant three score and the KSPT part I and II that measures severity of apraxia. This result indicates that the more severe the signs of CAS are, the more likely the child is to utilise a passive self-regulation strategy.

Lastly, the SP was used to examine the relationships between motor and process skills and scores on the SP. The aim of this study was to determine whether children with sensory processing deficits performed less well on an occupational performance measure. Although the aim of the study was not directed at establishing validity of the SP, the results of the study indicated that children who exhibited atypical sensory processing behaviours appear likely to demonstrate difficulties with occupational performance. The SP can be used to relate sensory processing problems with functional output due to strong construct validity.[71]

The Sensory Profile is currently one of the measurement instruments of sensory processing that is used on a frequent basis in research studies. This exposure to scientific investigation contributes to the SP's credibility as a reliable parent-

report measure of sensory processing. The SP has been used in conjunction with other measurement instruments, but correlation with other measurement tools has produced mixed results.

2.3.3 Sensory Profile School Companion

2.3.3.3 Description, Validity and Reliability

The Sensory Profile School Companion (SPSC, also referred to as the School Companion) (Annexure C) is a standardised assessment tool for measuring a student's (child's) processing abilities and their effect on the student's functional performance in the classroom and school environment. It is intended to be used as part of a comprehensive performance assessment of children, ages 3 years to 11 years 11 months. The Sensory Profile School Companion results, when combined with findings from the Sensory Profile caregiver questionnaire, provide a comprehensive view of a student's performance in different contexts. The teacher and caregiver each provide unique perspectives of the student's performance.[72]

The questionnaire consists of 62 items. The items are organised into sensory groups: auditory, visual, movement, touch and behaviour. The teacher who has routine contact with the child completes the questionnaire by reporting the frequency with which behaviours occur (almost always, frequently, occasionally, seldom, or almost never). The items address activities and behaviours that are familiar to most classroom settings. The Sensory Profile School Companion is organised into sensory groups and results indicate which sensory systems may be interfering with the child's performance. Responses are scored and the occupational therapist looks at performance patterns that may indicate sensory processing difficulties. The questionnaire yields four quadrant scores (registration, seeking, sensitivity and avoiding), four school factor scores (school

factors 1, 2, 3 and 4) and section scores for four sensory groups and one behaviour group (auditory, visual, movement, touch, and behaviour).[72]

The quadrant scores reflect the child's responsiveness to sensory experiences. Seeking and registration patterns indicate high threshold responses. Sensitivity and avoiding reflect low threshold responses.[72]

The standardisation sample of the Sensory Profile School Companion included ratings for over 700 children rated by 118 teachers from across the United States of America. Sixty two teachers rated 585 children without disabilities and 61 teachers rated 127 children with disabilities (ADHD, Asperger syndrome and autistic disorder). All the teachers who rated children with disabilities had a degree at bachelor's level or higher.[73]

Two statistical methods of analysis were used to estimate reliability: Internal consistency (coefficient alpha), and test-retest stability. Internal consistency coefficients assist to evaluate how homogenous the item responses are within a scale. Coefficient alpha is an index of internal consistency with values ranging from 0 (no consistency) to 1 (perfect consistency). Cronbach's Alpha was used to calculate internal consistency for each quadrant, school factor and section grouping. The alpha coefficients for the various groupings of items ranged from 0.83 to 0.95, indicating a high degree of internal consistency.[74]

Test-retest reliability was measured by having teachers complete the questionnaire a second time within a period of 1 to 21 days after completing it the first time with a sample of 126 children. Test-retest reliability was calculated using the Pearson product moment calculation coefficient. The reliability coefficients range from 0.80 to 0.95 and reflect good to excellent stability of the scores from the first rating to the second rating.[74]

Analysis of data provided evidence of validity of the Sensory Profile School Companion. The Standards for Educational and Psychological Testing (American Educational Research Association) served as primary resource for research guidelines and provided criteria for the evaluation of tests, testing practices and the effects of test use. Validity evidence related to the test content was established by doing an exploratory study, interviewing teachers and school-based occupational therapists and collecting data for pilot studies. The correlation of the School Companion with the Sensory Profile revealed moderate criterion relationships. The findings from special group studies provide evidence of the School Companion's ability to identify children with and without sensory processing difficulties. Analysis of data from the School Companion suggests that the test is a valid measure for identifying sensory processing strengths and concerns in children.[74]

2.4 CONCLUSION

There is an abundance of information in literature on Developmental Dyspraxia and Sensory Modulation Dysfunction. The past three decades has witnessed considerable development in occupational therapy literature regarding perspectives on Developmental Dyspraxia. These perspectives have evolved from Sensory Integration Theory to include Motor Learning- and Dynamical Systems Theories. Motor Learning Theory and Dynamical Systems Theory amalgamated with Sensory Integration Theory have allowed occupational therapists to consider not only a hierarchical model of the CNS in their approach to intervention, but also to conceptualise the CNS as multi-level and multi-system.[29] It has also highlighted the importance of task and context in assessment and treatment of this dysfunction.

The combination of a Sensory Integration Theory and a Motor Learning Theory have added value to frames of reference that are used to asses and treat developmental Dyspraxia. A motor learning frame of reference has brought about

a different level of understanding of how motor skill acquisition and motor learning principles fit in with the three practic stages described by Ayres. For the purpose of this study it has provided a theoretical foundation to the hypothesis of this study. It has also supplied an important link with sensory modulation in terms of how sensory detection fits in with the three stages of praxis. This expansion of approaches and views on Developmental Dyspraxia also supports a link between sensory detection (a process of sensory processing) and motor learning through an Information Processing Model. Although Miller et al recognise the fact that dyspraxia can occur in the presence of SUR or SOR, evidence has been lacking in literature that supports a close and consistent relationship.

In addition, there is a need to differentiate between the diverse perspectives on Sensory Modulation Disorder patterns in the literature. The classification of Sensory Modulation Disorder by Miller et al into three sub-patterns requires the alignment of this proposed model with existing sensory modulation classification models, such as Dunn's Model. For the purpose of this study it is thus essential to combine sensory modulation diagnostic terminology (Dunn[46]) with literature where Sensory Modulation Disorder is classified into sub-patterns (Miller[9]) in order to prevent confusion.

Dunn[75] proposed four quadrants that characterise a child's sensory modulation patterns when assessing with the SP or SPSC. They are low registration, sensation seeking, sensory sensitivity and sensation avoiding. These four quadrants or patterns can be incorporated into the two sub-types of Sensory Modulation Disorder classification by Miller[9]. Here sensation seeking and low registration represent the sub-pattern sensory under-responsiveness, and sensory sensitivity and sensation avoiding represent the sub-pattern sensory over-responsiveness. Sensory over- or under-responsivity in turn is thought to influence sensory detection and the tendency not to notice or notice too much sensory information.

It is evident from the literature review that many perspectives exist on the constructs relevant to this study. Some of these perspectives form the foundation for the hypothesised relationship between Developmental Dyspraxia and Sensory Responsivity.

2.5 SUMMARY

In the literature review a detailed overview was given about the theories that underpin the concepts Developmental Dyspraxia and Sensory Modulation Dysfunction. Different types of Developmental Dyspraxia and Sensory Modulation Dysfunction were explained and theories pertaining to the different constructs were linked under the overarching domain of occupational therapy. A discussion followed of how sensory detection and the different stages of praxis are linked. The void that exists in literature about empirical evidence that supports a relationship between Developmental Dyspraxia and Sensory Responsivity was also mentioned.

The measurement instruments used and a description of related evidence were given to ensure that the reader is well-informed about the suitability for use and statistical soundness of these measurement instruments. The use of the measurement instruments in a variety of research studies was also discussed to provide additional background.

In Chapter 3 the selected research methodology will be discussed.

CHAPTER 3

RESEARCH DESIGN AND METHOD

3.1 INTRODUCTION

In this chapter the research design is discussed as well as the methodology of this research study. The research aim and objectives are listed for clarification, even though they were stated in Chapter 1. Furthermore, the research hypotheses are given. Together with the research design and methodology, ethical considerations are listed as well as a discussion of the measurement instruments in terms of their intended use, scoring and interpretation. A discussion of the procedures regarding data collection is also provided.

3.2 AIM AND OBJECTIVES

The aim of this research study was to investigate the relationship between Developmental Dyspraxia and Sensory Responsivity.

The research objectives were as follows:

To establish whether a relationship exists between Developmental Dyspraxia and Sensory Over- or Under Responsivity.

To determine if specific types of Developmental Dyspraxia are related to Under-responsivity or Over-responsivity of specific sensory systems.

To investigate if specific items on the Sensory Profile and School Companion are related to specific types of Developmental Dyspraxia.

3.3 HYPOTHESES FOR AIMS AND OBJECTIVES

Null hypothesis

There is no relationship between Developmental Dyspraxia and Sensory Under-Responsivity.

Alternative hypothesis

There is a relationship between Developmental Dyspraxia and Sensory Under-Responsivity.

Null hypothesis

There is no relationship between Developmental Dyspraxia and Sensory Over-Responsivity.

Alternative hypothesis

There is a relationship between Developmental Dyspraxia and Sensory Over-Responsivity.

Null hypothesis

Specific types of Developmental Dyspraxia are not related to Under- or Over-Repsonsivity in specific sensory systems.

Alternative hypothesis

Specific types of Developmental Dyspraxia are related to Under- or Over-Responsivity in specific sensory systems.

Null hypothesis

Specific items on the Sensory Profile and School Companion are not related to a specific type of Developmental Dyspraxia.

Alternative Hypothesis

Specific items on the Sensory Profile and School Companion are related to a specific type of Developmental Dyspraxia.

3.4 ETHICAL CLEARANCE AND IMPLEMENTATION

3.4.1 Ethical Clearance and Permission

Ethical clearance was obtained from the Faculty of Health Sciences Research Ethics Committee, University of Pretoria, certificate number S108/2008. Further clearance and permission to conduct this research study was obtained from:

- The Postgraduate Research Committee of the Healthcare Sciences Faculty of the University of Pretoria.
- The Academic Advisory Committee of the University of Pretoria.
- The Faculty Board of the Faculty of Health Sciences of the University of Pretoria.
- Education Departments of Gauteng, Free State and Western Cape.

3.4.2 Informed Consent

Informed consent (Annexure D) was obtained from the parents/caregivers of the subjects for the use of the data collected through tests and questionnaires. Informed consent (Annexure E) was obtained from teachers and principals of schools where the school did not fall under the jurisdiction of the Provincial Education Department. To ensure confidentiality, informed consent forms from parents, teachers and principals as well as assent forms from subjects were obtained by the occupational therapists. The researcher gave clear instructions to recruited occupational therapists to emphasise to parents/caregivers, teachers and subjects that participation in the study is voluntary and that they were allowed to withdraw from the study at any stage should they wish to do so. This information was conveyed telephonically as well as in writing (Annexure F).

Occupational therapists that are trained and certified in the use of the SIPT were recruited by the researcher to provide data from their respective practices.

Informed consent forms were sent by registered mail, e-mail or delivered in person to recruited therapists. This arrangement also applied for the return of the forms. Occupational therapists recruited to the study were carefully selected on the grounds of their expertise and the standard of ethical and professional integrity. A total of 22 occupational therapists were recruited of whom 10 actively contributed to the research study. Informed consent (Annexure G) was also obtained from participating occupational therapists.

Children aged seven to eight years were asked for assent for the data from the SIPT, SP and SPSC to be used in the study. (Annexure H)

The researcher kept all informed consent forms secured in safe storage.

3.4.3 Confidentiality

Confidentiality was at all times guaranteed and relevant information such as the subjects' initials, chronological age, gender and hand preference was handled with great care during processing of test results. This information was not transferred to data-recording spreadsheets.

Confidentiality of information obtained from teachers who completed the School Companion was ensured by sending a School Companion teacher questionnaire to the teacher via the parent or subject. The completed questionnaire was returned to the occupational therapist in a sealed envelope. A seal was placed on the closed envelope to secure the content of the envelope and ensure that information provided by the teacher remained confidential.

3.4.4 Access to Intervention and Information

Subjects tested for the purpose of this study were offered intervention if Developmental Dyspraxia was identified or they were referred to the appropriate professionals for intervention or support. Information regarding the testing was made available and test reports containing recommendations were provided to parents or caregivers of subjects tested. The contact information of the researcher was made available to all subjects' parents in case they required additional information regarding test results or the research study.

3.4.5 Beneficence

Testing of subjects was performed by occupational therapists trained and certified in sensory integration assessment and treatment. Procedures related to testing were performed according to prescribed administration guidelines. Care and precautionary measures were taken during assessment to ensure physical safety and emotional wellbeing of the subjects.

3.5 METHODOLOGY

3.5.1 Research Design

The research study is a non-experimental research study. A correlational study was conducted, as the relationship among variables was studied.[76] The study was directed at examining the relationship between the independent variable (Developmental Dyspraxia) and the dependent variable (Sensory Responsivity) and did not investigate cause-and-effect.[76]

3.5.2 Sample

3.5.2.1 Selection Criteria

The following criteria were applied in the selection of suitable subjects for the research study:

- Diagnosis of Developmental Dyspraxia through assessment with the SIPT.
- Children aged 4 years through 8 years 11 months.[47]
- Children who are Afrikaans or English speaking, as SIPT instructions are only available in English or Afrikaans.
- Children diagnosed with Developmental Dyspraxia who did not receive therapy in between the period that they were assessed with the SIPT and the caregivers and teachers completed the Sensory Profile and School Companion.

The following exclusion criteria were used to ensure that the sample was not contaminated by underlying neurological conditions that are not considered purely developmental in nature:

- Children diagnosed with congenital or cognitive disabilities, acquired or traumatic brain injury or clinically significant neurological damage were excluded from the study due to the fact that Developmental Dyspraxia is a developmental dysfunction associated with Sensory Processing Disorder and is not caused by the above-mentioned conditions.

3.5.2.2 Timeframe

Sample selection occurred from August 2008 to the end of June 2009, in other words during the process of data collection. Subjects who complied with the inclusion criteria were added to the sample as testing of children took place and continued throughout the data collection phase.

3.5.2.3 Sample Size

The actual sample size of this study comprised of 73 subjects, though the recommended size of the sample was 60-90 subjects. The size of the sample was initially bigger, but seven subjects were discarded due to caregivers failing to give informed consent. Table 3.1 gives a breakdown of the sample according to gender and age.

Table 3.1 Layout of Subjects in Terms of Age and Gender

	4 years	5 years	6 years	7 years	8 years
Male	11	21	11	4	2
Female	5	5	5	6	3

3.5.2.4 Sampling Procedure

Purposive sampling was done as the researcher selected subjects according to specific inclusion and exclusion criteria and diagnosis. Purposive sampling also applied as the researcher handpicked contributing occupational therapists on the ground of their expertise, skill, experience and knowledge. The sample included subjects from four major cities in South Africa namely Pretoria, Johannesburg, Bloemfontein and Cape Town. Occupational therapists certified in the use of the SIPT and trained in Sensory Integration theory and treatment were recruited to provide data of subjects tested on the SIPT and diagnosed with Developmental Dyspraxia. These cities were selected because there is a higher concentration of occupational therapists that are certified in the use of the SIPT.

3.6 MEASUREMENT MATERIALS AND TOOLS

Reliability and accuracy of data obtained from the tests rely on the skill and expertise of the tester to administer the tests correctly and according to prescribed norms. Accuracy in scoring and interpretation is guaranteed through

use of computerised scoring of all measurement instruments. The following measurement instruments were used to gather data for the study.

3.6.1 Sensory Integration and Praxis Tests (SIPT)

The SIPT was used to diagnose Developmental Dyspraxia (independent variable). The test was scored and interpreted through the use of computerised scoring, where the subject's raw scores were entered into the SIPT scoring programme and raw scores were converted to standard deviation (SD) scores. SIPT test results are expressed in SD scores. SD scores are used in a standardised way of presenting test results relative to the normative sample. SD scores are also referred to as z-scores.[77]

Average SD scores fall between -1 and +1. Scores below -2 indicate problems and scores between -1 and -2 indicate possible problems. SD scores are linear scores and it is therefore best to compare differences between individual subscales using SD scores.[77]

The SIPT computer report (Annexure I) uses separate norms for boys and girls, with a further differentiation of norms based upon age groupings into 4-month intervals for younger children and 6-month intervals for older children.[77] The SIPT computer generated report consists of a 15 page report that contains a) a brief description of each test and the obtained standard score for each test administered; b) a summary bar graph that show the major results, a table that shows the estimated true score for each major SIPT score; c) standard error of measurement (SEM) and a frequency interval band of plus or minus two SEM from the estimated true score; d) a table of all SD scores for each of the 17 SIPT administered as well as limited interpretive text when the child's case is exceptional; e) a page listing measurements of lateral function; f) the D-square index of statistical fit of the child's profile to that obtained in key diagnostic groups; g) an audit of test data as recorded on the recording forms and; h) a

summary graph comparing the child's SD scores to the significant cluster group mean scores.[77] This report can be converted to rich text format. Contributing occupational therapists could therefore send the SIPT report electronically to the researcher via electronic mail.

3.6.2 Sensory Profile (SP)

The Sensory Profile Caregiver Questionnaire (Annexure B) was used to assess behaviours indicative of Sensory Modulation Dysfunction, thus sensory under- or-over-responsivity. This questionnaire was completed by the subject's caregiver or parent.

The Sensory Profile caregiver questionnaire's responses are scored as follows: always= 1 point, frequently= 2 points, occasionally = 3 points, seldom = 4 points and never = 5 points. The section scores of the Sensory Profile are computed by adding the points in each section and plotting the section raw scores on the child's responses on each section (auditory, visual, vestibular, touch, oral, sensory etc.) Item scores are also transferred to the factor grid to compute factor raw scores and then plotted on the factor summary grid. The factor summary grid (Annexure B) summarises the nine factors identified through factor analysis on various populations. Item scores are also transferred to the quadrant grid to compute quadrant raw score totals. These quadrant raw score totals are then plotted on the quadrant summary grid.[75] Refer to Annexure B for the SP summary score sheet.

A computer software package (Sensory Profile Select Scoring Assistant) was used to score and plot scores of the Sensory Profile. This aided to exclude computation mistakes during scoring of the Sensory Profile and contributed to accuracy of data in terms of section scores and quadrant scores.

3.6.3 Sensory Profile School Companion (SPSC)

The SPSC Teacher Questionnaire (Annexure C) was used to assess behaviours related to Sensory Modulation Dysfunction, specifically pertaining to the subject's behaviour at school. Through this measurement tool it was possible to determine if the subject's behaviour was indicative of sensory under- or-over-responsivity.

Raw scores for the School Companion are calculated manually or electronically. The School Companion questionnaire items are scored by scoring each response as follows: almost always= 1 point, frequently= 2 points, occasionally = 3 points, seldom = 4 points and almost never = 5 points. A higher score indicates that a child is less responsive than peers. Item raw scores are added to obtain section raw scores and transferred to the section summary on the last page of the scoring summary (Annexure C).

The school factors (1, 2, 3 and 4) are calculated by transferring item raw scores to the appropriate factor column on the school factor grid on page 3 of the scoring summary. Item raw scores are added to obtain school factor raw score totals. The school factor raw score totals are then plotted with an X in the appropriate classification column on the school factor summary grid. Refer to Annexure C for the SPSC summary score sheet.

The quadrant grid is on page 2 of the scoring summary (Annexure C). Item raw scores are written in the quadrant columns to obtain a quadrant raw score total. The quadrant raw score totals are transferred to the quadrant summary below the quadrant grid. The quadrant raw score totals are then plotted with an X in the appropriate classification column for each quadrant.[78]

A computer software package (School Companion Select Scoring Assistant) was also used to compute section and quadrant scores of the SPSC. This ensured a certain degree of accuracy in the scoring of the questionnaire. It furthermore

enabled the researcher to provide electronic score reports to contributing occupational therapists for their own therapy records.

3.7 PROCEDURE

3.7.1 Data Collection

Data was collected by means of the following methods:

- Standardised tests, namely the Sensory Integration and Praxis Tests.
- Parent and teacher questionnaires, namely the Sensory Profile and Sensory Profile School Companion.

Data was collected by the researcher and recruited occupational therapists to provide data for the study. Potential occupational therapists who could contribute data were identified and recruited in the following manner:

- A list containing the names of the occupational therapists that were certified in the use of the SIPT as well as certified in sensory integration treatment was obtained from the South African Institute for Sensory Integration.
- The researcher identified therapists reputed for their level of skill, experience, expertise and professional integrity from the list.
- The selected therapists were either known by the researcher or were recommended by other contributing occupational therapists.
- Another factor that was considered in the recruitment of occupational therapists was the frequency of use of the SIPT by a therapist. The SIPT is a fairly new test in South Africa and due to the high cost of scoring software it is not regularly used by occupational therapists. It was thus a requirement that the contributing occupational therapist use the SIPT on a regular basis.

- These therapists were practicing in Johannesburg, Pretoria, Bloemfontein or Cape Town.
- The researcher contacted the selected therapists either telephonically or in person to ascertain if they were willing to provide data from their practices.
- Therapists were then given a covering letter (Annexure F) informing them of the procedures involved (data collection instruments, questionnaires and informed consent) to ensure that they fully understood what was expected of them.
- As soon as a therapist indicated that she was willing to contribute by providing data for the research study, she was given the informed consent forms as well as the Sensory Profile and School Companion questionnaires with clear instructions on how to preserve confidentiality during the process of data collection. Refer to Annexures B through H.

Data from measurement instruments were obtained in the following manner:

SIPT: Children tested with the SIPT and with a diagnosis of Developmental Dyspraxia were identified by the researcher and contributing occupational therapists as suitable candidates for the study. If a therapist was unsure whether a subject was a suitable candidate for the study, an electronic SIPT report was sent to the researcher and she then verified the eligibility of the subject. SIPT score reports were sent to the researcher by electronic mail, fax or collected by the researcher in person. The researcher also collected data through testing of children with the SIPT. The last page of the SIPT report was specifically used as it contained the data relevant to the study.

The Sensory Profile and the School Companion – The researcher and the recruited occupational therapists handed questionnaires to caregivers and teachers of subjects who were diagnosed with Developmental Dyspraxia. The occupational therapists returned the completed questionnaires to the researcher

via post and fax or the researcher collected the questionnaires in person. The researcher scored the questionnaires and a score report was generated for data recording.

The researcher endeavoured through constant contact with recruited occupational therapists to secure a high compliancy rate. This was done by:

- E-mail, telephonic contact and text messaging.
- Bi-weekly and monthly follow up to arrange data collection.

The following measures were taken to control for variables that may affect data collection or reliability of data:

Table 3.2 Measures of Control for Variables

Confounding Variables	**Control**
1. Various occupational therapists (OT's) tested children and provided data for study.	1. Occupational therapists must be certified users of the SIPT and must have completed their training in Sensory Integration.
2. Caregivers and teachers could have completed questionnaire incorrectly or only in part.	2. Clear and precise instructions were given on how to complete the questionnaire. Instructions were printed on the cover page of each questionnaire and the tests were standardised in this format.
3. Recruited occupational therapists might have been unfamiliar with the Sensory Profile School Companion and might not have known how to score it or interpret it. The School Companion was a recent addition to the Sensory Profile group of tests and might not	3. The Sensory Profile School Companion was scored by means of computer scoring and therapists were not required to score or interpret the School Companion. A computer generated report was sent to the OT.

have been widely used by occupational therapists.	
4. Data from the SIPT, SP and SPSC was recorded on a spreadsheet for subsequent data analysis. The transfer of data from one format to another could result in errors or faulty transfer of data.	4. Data was transferred onto a spreadsheet throughout the data collection phase to limit errors due to recording of large amounts of data. Once all data was recorded it was checked by the researcher and a helper. A formula was used to calculate scores of the SP and SPSC on the spreadsheet to also control and identify errors during data recording. This proved to be useful and assisted in correcting data recording errors.

3.7.2 Data Collection from Recruited Occupational Therapists

Data was collected in the following manner from recruited occupational therapists:

- SIPT reports were sent via electronic mail or fax to the researcher.
- Sensory Profile and School Companion questionnaires were either faxed or personally collected from therapists.
- Informed consent forms were faxed or personally collected by the researcher.
- Constant follow-up by the researcher was necessary to ensure that suitable data were provided by recruited therapists and that a big enough sample was obtained.

3.7.3 Data Recording

Data recording was done in the following manner:

- SIPT data was recorded through computer scoring and a computer generated report was used to obtain the SIPT data relevant to this study. This data could be found on the last page of the SIPT computer report. (Refer to Annexure I). The D-squared values of four SIPT groups indicating Developmental Dyspraxia were recorded on the data spreadsheet.
- The data from the SIPT, Sensory Profile and School Companion were recorded on a spreadsheet to create a general data structure. This data structure made it possible to compare subjects' scores of the SIPT and the Sensory Profile and School Companion with each other.
- The Sensory Profile and School Companion item scores were recorded on the spreadsheet. Section raw scores as well as quadrant scores for these tests were also recorded on the spreadsheet.

The levels of measurement for the measurement instruments are indicated in Table 3.3

Table 3.3 Levels of Measurement for Measurement Instruments

Measurement Instrument	Level of measurement
Sensory Integration and Praxis Tests	Interval Scale
Sensory Profile	Ordinal Measurement
Sensory Profile School Companion	Ordinal Measurement

3.7.4 Data Analysis

Basic descriptive statistical measures were used in the initial interpretation of the research study data. Subsequent statistical analyses were determined after

completion of data collection. To test for any significant differences among the means of three or more independent groups, non-parametric one-way analysis of variance (i.e. nonparametric ANOVA, such as, the extension of the median test for two independent samples and/or the Kruskal-Wallis one-way analysis of variance by ranks) were used as no specific or particular underlying distributional assumption(s) were needed. Linear regression and categorical data analysis (specifically the Chi-squared test) were used to analyse the data from the Sensory Profile and the School Companion. The level of (statistical) significance was taken as 95%.

3.8 CONCLUSION

The process of data collection proved to be more challenging than expected. Relying on colleagues for the provision of data to ensure a big enough sample presented many operational challenges and required resourcefulness as well as good problem solving skills. Continuous follow-up, monitoring the content of data and keeping track of incoming data were essential to ensure reliability and suitability of data. Time constraints were a big factor contributing to non-compliance of therapists who initially indicated that they would be willing to provide data for the research study. This type of research method should preferably be undertaken with the help of research assistants and over a longer period of data collection.

3.9 SUMMARY

In this chapter the ethics and methodology concerning this study was discussed. The research aim and objectives were listed together with the research hypothesis.

Ethical clearance and implementation were discussed in terms of the measures that were required to ensure confidentiality. Another important factor was maintaining ethical standards when making use of occupational therapists that provided data from their practices. The measures that were implemented are presented in Section 3.4.

Methodology included the research design, which in this study is a non-experimental correlational study. This design was selected because a relationship among variables was investigated. Sample selection was based on specific inclusion criteria to ensure reliability of data, while the sample size at the end of data collection comprised of 73 subjects. Purposive sampling was done because selection of suitable subjects depended on the expertise of the therapist who performed the evaluation.

The measurement tools used in this study were the SIPT, the Sensory Profile and the School Companion. Data was obtained from the SIPT in the form of a computer generated report. Software scoring packages were used to score the Sensory Profile and School Companion questionnaires to ensure accuracy and reliability of data. The data provided by recruited occupational therapists were mostly faxed or sent by electronic mail to the researcher. D-squared values indicating patterns of dysfunction of the SIPT were used for the purpose of this study while item scores, section raw scores, and quadrant scores from the Sensory Profile and School Companion were used.

Data was collected by the researcher and occupational therapists recruited to provide data from their practices. This required careful explanation and clear instructions regarding the process of data collection to contributing therapists. Continuous follow up, regular contact via telephone, text messaging and electronic mail, and motivating therapists was essential to ensure compliance of recruited occupational therapists. Data collection took place over a period of nine

months until a big enough sample was obtained. Out of an initial pool of 22 occupational therapists only 10 actively contributed to the study.

Data was recorded on a spreadsheet to provide a data structure that would allow comparison of scores between different tests.

In the next chapter the results of the research study will be discussed in terms of the research aim and objectives.

CHAPTER 4

RESEARCH RESULTS

4.1 INTRODUCTION

In this chapter the results of the research study will be discussed in terms of how they relate to the research aim and objectives, given in Section 1.4.

This chapter will be divided into sections that represent the research aim and objectives. Section 4.2 represents the research aim followed by Section 4.3 through 4.5 that respectively cover the results related to research Objectives 1 to 3. Some of the sections are sub-divided to accommodate reporting of results of additional analysis.

The results generated from statistical analysis will be given by firstly reporting the method of analysis and then reporting the results. These results will be discussed in terms of the findings and interpretation of the findings. Sub-conclusions that briefly summarise the results will be given at the end of each section.

In addition to the statistical analyses, clinical analysis of the data set is offered. This will be given in Section 4.6, which will consist of an introduction to the clinical analyses followed by graphs and discussion of the information contained in the graphs. A sub-conclusion will also be given to briefly summarise the results.

4.2 CORRELATION BETWEEN DEVELOPMENTAL DYSPRAXIA AND SENSORY RESPONSIVITY

The research aim was to establish if a relationship existed between Developmental Dyspraxia and Sensory Responsivity.

4.2.1 Exploratory Analysis of Data

Exploratory analysis of the data set was conducted to determine if a relationship between Developmental Dyspraxia and Sensory Responsivity is visually represented in a scatterplot. Figure 4.1 is one example of such a scatterplot.

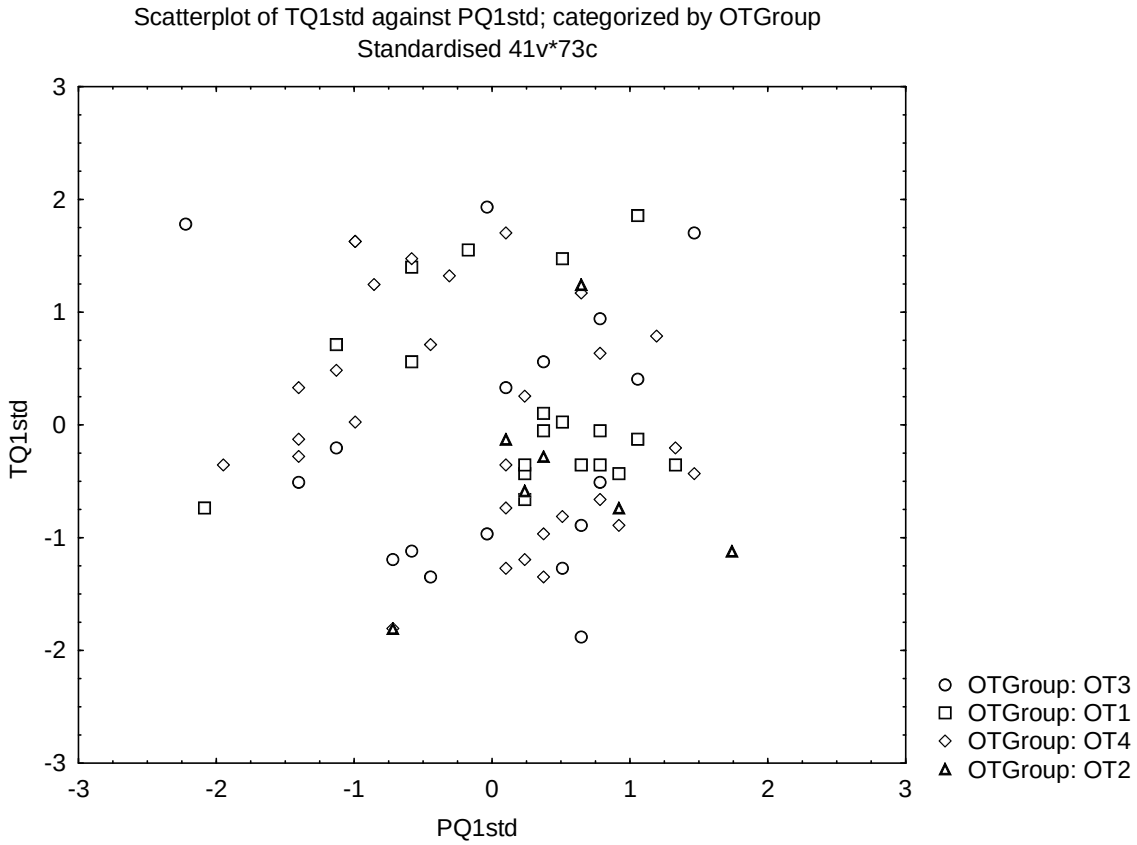

Figure 4.1 Exploratory Analysis: Scatterplot of the Distribution of SIPT Groups in Quadrant 1 of the SP and SPSC

The scatterplot in Figure 4.1 depicts the spread of SIPT groups in the first quadrant of the SP and SPSC. The abbreviations in the scatterplot are explained below:

- OT Group 1 = SIPT 1: Bilateral Integration and Sequencing deficit
- OT Group 2 = SIPT 2: Generalised SI dysfunction
- OT Group 3 = SIPT 3: Dyspraxia on verbal command
- OT Group 4 = SIPT4: Visio- and somatodyspraxia
- PQ 1 std: SP quadrant 1 standardised
- TQI std: SPSC quadrant 1 standardised

There is no observable grouping of SIPT groups in Figure 4.1, which infers that there is no significant pattern that points to a relationship between quadrants 1 of the SP and SPSC and the SIPT groups.

4.2.2 Data Analysis

To determine if a relationship existed between Developmental Dyspraxia and sensory responsivity, a correlational analysis was done between the SIPT groups that indicate Developmental Dyspraxia and the individual quadrant scores of the SP and SPSC. A non-parametric test, namely the Spearman's rank-order correlation coefficient, was used to calculate the relationship between variables.

4.2.3 Results and Interpretation

The results of the correlation of the four SIPT groups and the SP and SPSC quadrant scores are represented in Table 4.1.

Table 4.1 Correlation between SIPT Groups and Quadrant Scores of the SP and the SPSC

Spearman Correlation Coefficient N= 73 Rho= 0				
SIPT 1 = BIS deficit SIPT 2 = Generalised SI dysfunction		SIPT 3 = Dyspraxia on verbal command SIPT 4 = Visio- and somatodyspraxia		
	SIPT 1	**SIPT 2**	**SIPT 3**	**SIPT 4**
SP Quad 1 std Registration	-0.176	0.071	-0.055	0.006
Significance (p)	0.134	0.55	0.643	0.955
SP Quad 2 std Sensory Seeking	-0.133	0.022	0.009	-0.010
Significance (p)	0.258	0.850	0.935	0.927
SP Quad 3 std Sensory Sensitive	-0.238	-0.023	-0.170	-0.070
Significance (p)	0.042	0.840	0.148	0.555
SP Quad 4 std Sensation Avoiding	-0.156	0.064	0.010	-0.018
Significance (p)	0.186	0.586	0.928	0.876
SPSC Quad 1 std Registration	-0,167	0.189	0.007	-0.000
Significance (p)	0.157	0.108	0.950	0.998
SPSC Quad 2 std Sensory Seeking	0.140	-0.063	-0.048	0.090
Significance (p)	0.235	0.595	0.680	0.444
SPSC Quad 3 std Sensory Sensitive	-0.055	-0.018	-0.146	-0.110
Significance (p)	0.638	0.875	0.216	0.349
SPSC Quad4 std Sensation Avoiding	-0.228	0.214	0.009	-0.102
Significance (p)	0.052	0.068	0.938	0.389
Correlation is significant at the level 0.05				

The results in Table 4.1 indicate the following correlations:

- A significant weak negative correlation between SIPT 1 (Bilateral Integration and Sequencing deficit [BIS]) and quadrant 3 (SP) (sensory sensitivity) ($p = 0.042$; $r = -0.238$). This suggests that the closer the fit to a BIS deficit the smaller the tendency of sensory over-responsivity (sensory sensitivity).
- A significant weak negative correlation between SIPT 1 (BIS deficit) and quadrant 4 (SPSC) (sensation avoiding) ($p = 0.052$; $r = -0.228$). This implies that the closer the fit to a BIS deficit the smaller the tendency of sensory over-responsivity.
- A weak positive correlation between SIPT 2 (generalised SI dysfunction) and quadrant 4 (SPSC) (sensation avoiding) ($p = 0.068$; $r = 0.214$). This implies that the closer the fit with generalised SI dysfunction, the greater the tendency of sensory over-responsivity.

4.2.4 Conclusion

There were two weak negative correlations between a BIS deficit (SIPT 1) and quadrant 3 of the SP and quadrant 4 of the SPSC. This negative correlation implies an inverse weak relation between BIS and sensory sensitivity and sensation avoidance. There was a weak positive correlation between a generalised SI dysfunction (SIPT 2) and quadrant 4 of the SPSC, which implies a weak relation between sensation avoidance and generalised SI dysfunction.

4.3 CORRELATION BETWEEN DEVELOPMENTAL DYSPRAXIA AND SENSORY UNDER RESPONSIVENESS AND SENSORY OVER RESPONSIVENESS

The first research objective was to determine if a relationship existed between Developmental Dyspraxia and Sensory Under-Responsiveness (SUR) or Sensory Over-Responsiveness (SOR).

4.3.1 Data Analysis

Analysis of the relationship between the combined quadrant 1 and 2 scores of the SP that represent SUR, and the four SIPT groups was done. This procedure was also done for combined quadrants 3 and 4 of the SP that represent SOR and the four SIPT groups. The SPSC combined quadrant 1 and 2, and 3 and 4 scores were also correlated with the four SIPT groups. This was done to determine the relation between SOR of the SP and SPSC and the four SIPT groups and SUR of the SP and SPSC and the four SIPT groups. Spearman's rank-order correlation coefficient was used. Results are given in Table 4.2

Table 4.2 Correlations between Four SIPT Groups and Combined Quadrant Scores of SP and SPSC that Represent SUR and SOR

Spearman Correlation Coefficients, N = 73 **Prob > |r| under H0: Rho=0**				
SIPT 1 = BIS deficit SIPT 2 = Generalised SI dysfunction SUR = Sensory under-responsiveness			SIPT 3 = Dyspraxia on verbal command SIPT 4 = Visio- and somatodyspraxia SOR = Sensory over-responsiveness	
	SIPT1	**SIPT2**	**SIPT3**	**SIPT4**
SP Quad 1&2 (SUR)	-0.20855	0.04749	-0.02177	-0.02907
Significance	0.0766	0.6899	0.855	0.8072
SP Quad 3&4 (SOR)	-0.20503	0.02945	-0.06394	-0.04878
Significance	0.0818	0.8047	0.591	0.6819
SPSC Quad 1&2 (SUR)	-0.04671	0.08786	-0.05378	0.0315
Significance	0.6948	0.4598	0.6513	0.7913
SPSC Quad 3&4 (SOR)	-0.19138	0.13796	-0.0703	-0.12706
Significance	0.1048	0.2444	0.5545	0.2841
Correlation significant at the level 0.05				

The results in Table 4.2 depict an inverse correlation between the following:

- A weak inverse correlation between SUR (SP) and SIPT 1 (BIS deficit) ($p = 0.076$; $r = -0.208$). The closer the fit to a BIS deficit, the smaller the tendency of SUR measured with the SP.
- There was also a weak inverse correlation between SOR (SP) and SIPT 1 (BIS deficit) ($p = 0.081$; $r = -0.205$), suggesting that the closer the fit to a BIS deficit, the smaller the tendency of SOR.

4.3.2 Additional Analysis

The correlation of combined quadrant 1 and 2 scores of the SP and SPSC with the four SIPT groups and combined quadrant 3 and 4 scores of the SP and SPSC with the four SIPT groups was done. This was done to look at the global relation of SUR and SOR with the four SIPT groups that represent Developmental Dyspraxia. Spearman rank-order correlation coefficient was used to compute correlations. The results are given in Table 4.3

Table 4.3 Correlation between Four SIPT Groups and SOR and SUR

Spearman Correlation Coefficients, N = 73 **Prob > |r| under H0: Rho=0**				
SIPT 1 = BIS deficit SIPT 2 = Generalised SI dysfunction SUR = Sensory under-responsiveness			SIPT 3 = Dyspraxia on verbal command SIPT 4 = Visio- and somatodyspraxia SOR = Sensory over responsiveness	
	SIPT1	**SIPT2**	**SIPT3**	**SIPT4**
SP & SPSC (SUR)	-0.189	0.132	-0.023	-0.028
Significance	0.108	0.263	0.840	0.811
SP & SPSC (SOR)	-0.239	0.129	-0.031	-0.064
Significance	0.041	0.275	0.790	0.588
Correlation significant at the level 0.05				

The results in Table 4.3 reveal a significant weak negative correlation between SOR and a BIS deficit (p = 0.041; r = -0.239). This suggests that the closer the fit is to a BIS deficit (SIPT 1), the smaller the tendency of SOR.

4.3.3 Conclusion

Results from data analysis that examine the relationship between Developmental Dyspraxia and Sensory Under- or Over Responsiveness revealed a weak inverse correlation between SOR and SUR of the SP and a BIS deficit (SIPT 1). It also revealed a significant weak inverse correlation between SOR (SP and SPSC combined) and a BIS deficit (SIPT 1).

4.4. CORRELATION BETWEEN SENSORY SYSTEMS AND DEVELOPMENTAL DYSPRAXIA

The second objective of this research study was to determine if specific types of Developmental Dyspraxia were related to under- or over-responsivity of specific sensory systems.

4.4.1 Data Analysis

The Spearman rank-order correlation coefficient was used to compute the correlations. The results of the data analysis of this section will be explained in two sub-sections:

4.4.1.1 Correlation between SIPT Groups and SUR and SOR in Sensory Systems

The following sensory systems of both the SP and SPSC were included when computing this correlation:

- Auditory

- Visual
- Vestibular/movement
- Touch
- Oral sensory (SP only)

The SP and SPSC sections were split into subsections that represent SUR and SOR and these scores were correlated with the four SIPT groups. The results are given in Table 4.4

Table 4.4 Correlation between SIPT Groups and SUR and SOR of Sensory Systems of the SP and SPSC

Spearman Correlation Coefficients, N = 73 **Prob > |r| under H0: Rho=0**				
SIPT 1 = BIS deficit SIPT 3 = Dyspraxia on verbal command SIPT 2 = Generalised SI dysfunction SIPT 4 = Visio- and somatodyspraxia SUR = Sensory under-responsiveness SOR= Sensory over-responsiveness				
	SIPT 1	**SIPT 2**	**SIPT 3**	**SIPT 4**
SP AUD SOR	-0.16421	-0.04613	-0.07543	-0.16511
Significance	0.1651	0.6983	0.5259	0.1627
SP AUD SUR	-0.17544	-0.07289	0.00438	-0.24685
Significance	0.1376	0.54	0.9707	0.0353
SP VIS SOR	0.00601	0.07724	0.1769	0.06204
Significance	0.9598	0.516	0.1343	0.6021
SP VIS SUR	-0.09458	0.05311	0.14832	-0.07162
Significance	0.4261	0.6554	0.2105	0.5471
SP VESTIB SOR	-0.13112	0.06118	-0.00148	0.08137
Significance	0.2688	0.6071	0.9901	0.4937

Spearman Correlation Coefficients, N = 73 **Prob > |r| under H0: Rho=0**				
SIPT 1 = BIS deficit SIPT 2 = Generalised SI dysfunction SUR = Sensory under-responsiveness			SIPT 3 = Dyspraxia on verbal command SIPT 4 = Visio- and somatodyspraxia SOR= Sensory over-responsiveness	
	SIPT 1	**SIPT 2**	**SIPT 3**	**SIPT 4**
SP VESTIB SUR	-0.03525	-0.00093	0.07433	0.07233
Significance	0.7672	0.9938	0.532	0.5431
SP TOUCH SOR	-0.21779	-0.05959	-0.07846	-0.13847
Significance	0.0642	0.6165	0.5094	0.2427
SP TOUCH SUR	-0.04242	0.00383	0.03224	-0.03096
Significance	0.7216	0.9743	0.7865	0.7949
SP ORAL SOR	-0.12907	0.01139	-0.19092	0.00962
Significance	0.276	0.923	0.105	0.935
SP ORAL SUR	0.128	-0.070	-0.188	-0.102
Significance	0.277	0.555	0.110	0.388
SPSC AUD SOR	-0.24989	0.08616	-0.23103	-0.2286
Significance	0.033	0.4686	0.0492	0.0517
SPSC AUD SUR	-0.15595	0.1417	-0.01085	-0.00916
Significance	0.1877	0.2318	0.9274	0.9387
SPSC VIS SOR	-0.01694	0.04133	-0.06759	-0.03132
Significance	0.8869	0.7284	0.5699	0.7925
SPSC VIS SUR	-0.05909	0.12538	-0.02851	0.07927
Significance	0.6195	0.2905	0.8108	0.505

Spearman Correlation Coefficients, N = 73 **Prob > |r| under H0: Rho=0**				
SIPT 1 = BIS deficit SIPT 3 = Dyspraxia on verbal command SIPT 2 = Generalised SI dysfunction SIPT 4 = Visio- and somatodyspraxia SUR = Sensory under-responsiveness SOR= Sensory over-responsiveness				
	SIPT 1	**SIPT 2**	**SIPT 3**	**SIPT 4**
SPSC VESTIB SOR	-0.23371	0.22896	0.06207	-0.01553
Significance	0.0466	0.0514	0.6019	0.8962
SPSC VESTIB SUR	0.02072	0.03668	-0.03868	0.05269
Significance	0.8619	0.758	0.7452	0.658
SPSC TOUCH SOR	-0.20691	0.05205	-0.15125	-0.16748
Significance	0.079	0.6619	0.2015	0.1567
SPSC TOUCH SUR	-0.01635	0.08534	-0.06782	0.04271
Significance	0.8908	0.4728	0.5686	0.7198
Correlation significant at the level 0.05				

From the results in Table 4.4 the following significant correlations were observed:

- A significant weak negative correlation between SIPT 4 (visio- and somatodyspraxia) and SUR of the auditory system (p = 0.035; r = -0.246). This indicated that the closer the fit to visio- and somatodyspraxia (SIPT 4), the smaller the tendency of SUR in the auditory system.
- A weak negative correlation between SIPT 1 (BIS deficit) and SOR of the tactile system (p = 0.064; r = -0.217). This means that the closer the fit to a BIS deficit, the smaller the tendency of SOR of the tactile system.
- A significant weak negative correlation between SIPT1 (BIS deficit) and SOR of the auditory system (SPSC) (p = 0.033; r = -0.249). This indicated that the closer the fit to a BIS deficit, the smaller the tendency of SOR of the auditory system. This also held true for SIPT 3 (dyspraxia on verbal command) (p = 0.0492; r = -0.231) and SIPT 4 (visio- and

somatodyspraxia) (p = 0.0517; r = -0.228) and SOR of the auditory system (SPSC).

- A significant weak negative correlation between SIPT 1 (BIS deficit) and SOR of movement or the vestibular system (p = 0.046; r = -0.2337). This indicated that the closer the fit to a BIS deficit, the smaller the tendency of SOR of the vestibular system.
- A significant weak positive correlation between SIPT 2 (generalised SI dysfunction) and SOR of the vestibular system (SPSC) (p = 0.051; r=0.228). This indicated that the closer the fit to a generalised SI dysfunction, the greater the tendency of SOR of the vestibular system.
- A weak negative correlation between SIPT 1 (BIS deficit) and SOR of the tactile system (SPSC) (p = 0.079; r = -0.206). This indicated that the closer the fit was to a BIS deficit, the smaller the tendency of SOR of the tactile system.

4.4.1.2 Correlation between SIPT Groups and Sensory Systems

This subsection examines the correlation between SIPT groups and sensory systems of the SP and SPSC. The sensory systems are:

- Auditory
- Visual
- Vestibular
- Tactile
- Oral sensory (SP)

An additional section of both the SP and SPSC was added to this section, even though it did not represent a sensory system. This section (section 12 of the SP and section 5 of the SPSC) was the behavioural section and was used because specific avoidance behaviours are associated with behaviours displayed by children with Developmental Dyspraxia. The aim was to determine if these behaviours were related to a specific type of dyspraxia or if they purely reflect

behaviour associated with sensory modulation dysfunction. Results are given in Table 4.5.

Table 4.5 Correlation between SIPT Groups and Sensory Systems

Spearman Correlation Coefficients, N = 73 **Prob > |r| under H0: Rho=0**				
SIPT 1 = BIS deficit SIPT3 = Dyspraxia on verbal command SIPT 2 = Generalised SI dysfunction SIPT 4 = Visio- and somatodyspraxia				
	SIPT1	**SIPT 2**	**SIPT 3**	**SIPT 4**
SP AUD	-0.2005	-0.06537	-0.04598	-0.22563
Significance	0.089	0.5827	0.6993	0.0549
SP VIS	-0.03787	0.0649	0.18843	-0.01312
Significance	0.7504	0.5854	0.1104	0.9123
SP VESTIB	-0.14476	0.03762	-0.01738	0.07003
Significance	0.2217	0.752	0.884	0.556
SP TOUCH	-0.14941	-0.0677	-0.05559	-0.09669
Significance	0.2071	0.5693	0.6404	0.4158
SP ORAL	-0.13953	-0.02172	-0.19122	-0.04297
Significance	0.2391	0.8553	0.1051	0.7181
SP BEHAVIOUR	-0.06221	0.13774	0.09147	0.12995
Significance	0.6011	0.2452	0.4415	0.2732
SPSC AUD	-0.22698	0.09975	-0.16711	-0.15613
Significance	0.0535	0.4011	0.1576	0.1871
SPSC VIS	-0.05008	0.11023	-0.03841	0.02377
Significance	0.6739	0.3532	0.747	0.8418
SPSC VESTIB	-0.07173	0.10435	0.0221	0.03578
Significance	0.5465	0.3796	0.8528	0.7638

Spearman Correlation Coefficients, N = 73 **Prob > |r| under H0: Rho=0**				
SIPT 1 = BIS deficit SIPT3 = Dyspraxia on verbal command SIPT 2 = Generalised SI dysfunction SIPT 4 = Visio- and somatodyspraxia				
	SIPT1	**SIPT 2**	**SIPT 3**	**SIPT 4**
SPSC TOUCH	-0.1374	0.09534	-0.12908	-0.06213
Significance	0.2464	0.4224	0.2764	0.6015
SPSC BEHAVIOUR	-0.02428	0.08839	0.03493	-0.0319
Significance	0.8384	0.4571	0.7692	0.7887
Correlation significant at the level 0.05				

From the results in Table 4.5 the following correlations were observed:

- A weak negative correlation between SIPT 1 (BIS deficit) and the auditory system (SP) ($p = 0.089$; $r = -0.200$). The negative correlation suggested that the closer the fit to a BIS deficit the smaller the tendency of auditory under- or over responsivity.
- A significant weak negative correlation between SIPT 4 (visio- and somatodyspraxia) and auditory responsivity (SP) ($p = 0.054$; $r = -0.225$). Thus, the closer the fit to visio- and somatodyspraxia the smaller the tendency of sensory under- or over responsivity of the auditory system.
- A significant weak negative correlation between SIPT 1 (BIS deficit) and the auditory system (SPSC) ($p = 0.053$; $r = -0.226$), indicating that the closer the fit to a BIS deficit, the smaller the tendency of sensory over- or under responsivity of the auditory system.
- No correlation was found between behaviour (SP and SPSC) and any of the SIPT groups.

4.4.2 Conclusion

There were more correlations between Developmental Dyspraxia and SUR/SOR of the sensory systems of the SPSC than the SP. Most correlations were weak negative correlations with the different types of dyspraxia. There was a higher frequency of negative correlations with BIS deficits.

The correlation between the SIPT groups and sensory systems of the SP and SPSC revealed weak negative correlations between the auditory system and SIPT 1 (BIS deficit) and SIPT 4 (visio- and somatodyspraxia).

4.5 RESULTS OF RESEARCH OBJECTIVE 3

The third research objective was to determine if any of the items of the SP and SPSC showed a relation to any type of dyspraxia. In other words, to determine if a consistent pattern of item responses were associated with any of the SIPT groups.

4.5.1 Data Analysis

After consultation with the statistician and consideration of the results of the research aim and Objectives 1 and 2, which revealed no significant positive correlations, it was decided to rather examine the internal consistency reliability of the research data set obtained from the SP and SPSC. This was done by computing Cronbach Coefficient Alpha to assess internal consistency reliability of variables in sections of the SP and SPSC. It was decided to compute the alpha value of variables instead of sections, as section scores were used in correlational analysis to examine relationships with Developmental Dyspraxia.

Cronbach Coefficient Alpha of all variables of both the SP and SPSC was computed. Two sections of the SP and one section of the SPSC will be

discussed in terms of the computed results. A section of items (variables) with an acceptable internal consistency (alpha = 0.7) and a section of items (variables) with a low internal consistency (alpha lower than 0.7) of the SP will be given. Some of the items of sections that stand out and lower the correlation with the total will be given as an example.

4.5.2 Section 1 (Auditory Function) of the SP

Section 1 of the SP consisting of items 1-8 had an acceptable alpha value of 0.76, as can be seen in Table 4.6. Simple statistics, the alpha value as well as the Croncbach Coefficient Alpha with deleted variable are given below.

Table 4.6 Simple Statistics, Cronbach Coefficient Alpha and Cronbach Coefficient Alpha with Deleted Variable

8 Variables: Items 1-8 **Simple Statistics**						
Variable	**N**	**Mean**	**Std Dev**	**Sum**	**Min**	**Max**
Item 1	73	4.123	1.09221	301	1	5
Item 2	73	3.726	1.20485	272	1	5
Item 3	73	3.821	1.04539	279	1	5
Item 4	73	3.205	1.16618	234	1	5
Item 5	73	4.342	0.83698	317	1	5
Item 6	73	3	0.92796	219	1	5
Item 7	73	3.438	0.94261	251	1	5
Item 8	73	3.232	1.253	236	1	5

Cronbach Coefficient Alpha	
Variables	**Alpha**
Raw	0.76416
Standardised	0.77424

Cronbach Coefficient Alpha with Deleted Variable					
Deleted	**Raw Variables**		**Standardised Variables**		**Label**
Variable	**Correlation**	**Alpha**	**Correlation**	**Alpha**	
	with Total		**with Total**		
Item 1	0.489842	0.734	0.489475	0.747	Item 1
Item 2	0.512818	0.729	0.510894	0.743	Item 2
Item 3	0.644782	0.706	0.650112	0.719	Item 3
Item 4	0.643449	0.703	0.642779	0.720	Item 4
Item 5	0.415708	0.747	0.414023	0.760	Item 5
Item 6	0.48726	0.736	0.481718	0.748	Item 6
Item 7	0.516206	0.731	0.522189	0.741	Item 7
Item 8	0.106837	0.80897	0.125203	0.805	Item 8
Variables with low correlation with the total					

The alpha value for items 1-8 in Section 1 of the SP was 0.76416 (Raw) and 0.77424 (Standardised) which indicated a high internal consistency reliability, as 0.7 and above is acceptable. Item 8, however, showed the lowest correlation with the entire test, inferring that if Item 8 was deleted the alpha will improve by 0.15. So, in other words, if Item 8 was left out from the set of data, the consistency reliability of that set of data would be higher.

Item 8 received a mean (M) score of 3.232 and a SD of 1.253. Looking at the statement posed in Item 8 on the SP, the possible explanation for the low correlation with the total of this item could be the slant of the statement. The statement is posed in such a way to represent a problem, but may not necessarily be perceived as problematic behaviour by a parent or caregiver and therefore reported as being observed relatively frequently.

4.5.3 Section 3 (Vestibular Function) of the SP

The vestibular section of the SP had an alpha value of 0.65, as can be seen in Table 4.7. Simple statistics, the alpha value as well as the Croncbach Coefficient Alpha with deleted variable are given below.

Table 4.7 Simple Statistics of Variables of Section 3 (SP), Cronbach Coefficient Alpha and Cronbach Coefficient Alpha with Deleted Variable

11 Variables: Items 18-28 **Simple Statistics**						
Variable	**N**	**Mean**	**Std Dev**	**Sum**	**Min**	**Max**
Item 18	73	4.6575	0.6502	340	2	5
Item 19	73	4.5342	0.8988	331	1	5
Item 20	73	4.6575	0.7114	340	2	5
Item 21	73	4.8493	0.49078	354	2	5
Item 22	73	4.7534	0.49387	347	3	5
Item 23	73	4.8630	0.41883	355	3	5
Item 24	73	2.9863	1.23032	218	1	5
Item 25	73	2.7123	1.17236	198	1	5
Item 26	73	4.3972	0.75901	321	2	5
Item 27	73	4.5479	0.98659	332	1	5
Item 28	73	4.4657	0.8988	326	2	5

Cronbach Coefficient Alpha	
Variables	**Alpha**
Raw	0.65226
Standardised	0.682493

Cronbach Coefficient Alpha with Deleted Variable					
Deleted Variable	**Raw Variables**		**Standardised Variables**		**Label**
	Correlation with Total	**Alpha**	**Correlation With Total**	**Alpha**	
Item 18	0.175007	0.650181	0.213218	0.680697	Item 18
Item 19	0.097789	0.670576	0.144067	0.691798	Item 19
Item 20	0.194267	0.648111	0.324561	0.662215	Item 20
Item 21	0.266495	0.63962	0.323687	0.662363	Item 21
Item 22	0.476648	0.61628	0.543885	0.623543	Item 22
Item 23	0.273326	0.640745	0.346982	0.658401	Item 23
Item 24	0.412633	0.60772	0.349305	0.658005	Item 24
Item 25	0.272751	0.644646	0.183535	0.685497	Item 25
Item 26	0.323508	0.627101	0.241744	0.676034	Item 26
Item 27	0.468743	0.593079	0.427571	0.644433	Item 27
Item 28	0.559745	0.575534	0.554177	0.621652	Item 28
Item/s with a low correlation with the total					

The results in Table 4.7 revealed the following:

- In the case with variables of Section 3 of the SP (Items 18-28), the alpha value was 0.6522 (Raw) and 0.6824 (Standardised). The alpha was thus lower than the accepted cut-off of 0.7 and implied lower internal consistency reliability.
- The correlation of Items 18, 19, 20, 21, 23 and 25 with the total indicated a low correlation with the entire test. Should these items with a low correlation be deleted, the alpha value of the remaining items for that section would improve.
- The mean scores for items of the SP in this data set represented the responses in terms of frequency of observed behaviour. The response of the caregiver may be influenced by the subjective interpretation of a statement (item). The higher the mean, the less frequently behaviour is

observed. Items 18-21and 23 received mean scores ranging between 4.5 and 4.8, which indicated a high number of responses that reflected a low frequency of observing that behaviour. The tendency to select responses that represent a low frequency of observing behaviour could be due to the general tone of the statement leaning to either the negative or positive. Thus, if an item is posed in a negative manner and perceived as negative by a caregiver, the response selected may be “less frequent” observation of that behaviour. It may also be selected because the behaviour is not commonly displayed and is not observed on a daily basis.

- Further discussion of internal consistency reliability of the items of the SP and SPSC will be covered in Chapter 5.

4.5.4 Section 2 (Visual) of the SPSC

The Cronbach Coefficient Alpha of only one section of the SPSC is given because the SPSC tested with high internal consistency reliability. The section with the lowest alpha value is discussed. This section is Section 2, which is the visual section. Results are given in Table 4.8

Table 4.8 Simple Statistics of variables of Section 2 (SPSC), Cronbach Coefficient Alpha and Cronbach Coefficient Alpha with Deleted Variable

11 Variables: Items 11- 21 Simple Statistics						
Variable	**N**	**Mean**	**Std Dev**	**Sum**	**Min**	**Max**
Item 11	73	2.78082	1.27199	203	1	5
Item 12	73	3.08219	1.23326	225	1	5
Item 13	73	3.36986	1.29644	246	1	5
Item 14	73	3.42466	1.15371	250	1	5
Item 15	73	4.24658	0.92467	310	1	5
Item 16	73	2.87671	1.16601	210	1	5
Item 17	73	3.82192	0.91807	279	2	5

11 Variables: Items 11- 21 Simple Statistics						
Item 18	73	3.94521	0.8315	288	2	5
Item 19	73	2.72603	1.27214	199	1	5
Item 20	73	3.52055	1.28138	257	1	5
Item 21	73	3.56164	1.30156	260	1	5

Cronbach Coefficient Alpha	
Variables	**Alpha**
Raw	0.701041
Standardised	0.654874

Cronbach Coefficient Alpha with Deleted Variable					
Deleted Variable	**Raw Variables**		**Standardised Variables**		**Label**
	Correlation with Total	**Alpha**	**Correlation With Total**	**Alpha**	
Item 11	0.622374	0.630206	0.559456	0.583262	Item 11
Item 12	0.554523	0.644214	0.485727	0.598179	Item 12
Item 13	0.589559	0.635758	0.537126	0.587822	Item 13
Item 14	0.316396	0.685305	0.306464	0.632786	Item 14
Item 15	-0.204822	0.74574	-0.165387	0.713312	Item 15
Item 16	0.415652	0.669439	0.383761	0.618149	Item 16
Item 17	-0.016811	0.724888	0.043366	0.679499	Item 17
Item 18	-0.02455	0.722788	0.02635	0.68236	Item 18
Item 19	0.616437	0.631348	0.604478	0.573951	Item 19
Item 20	0.453712	0.66173	0.417028	0.611717	Item 20
Item 21	0.319221	0.685901	0.286327	0.63653	Item 21
Item/s with a low correlation with the total					

The results in Table 4.8 reveal the following:

- The alpha for variables of Section 2 (visual) of the SPSC was 0.701 (Raw) and 0.654 (Standardised). The variables of this section of the SPSC had

the lowest alpha value of the entire test, which indicated otherwise good internal consistency of the data from the SPSC.

- The variables (items) 15, 17 and 18 had low negative correlations with the total. The mean scores (M) and standard deviations (SD) for Items 15, 17 and 18 respectively were: M = 4.246 and SD = 0.924; M = 3.821 and SD = 0.918; M = 3.945 and SD = 0.831.
- The mean reflected the frequency with which observed behaviours occurred, where a high mean indicated lower frequency of observing behaviour and a low mean indicated a high frequency of behaviours occurring.
- Items 15, 17 and 18 had the lowest standard deviations in this group of items with the highest means and therefore did not correlate with the rest of the items. With these items, the responses had very little variance and a small dispersion from the mean. This could have been due to the wording of the statements representing the items, or choosing the safest response option in the middle.

A summary of the Cronbach Coefficient Alpha for the variables of sections of the SP and the SPSC are given in Tables 4.9 and 4.10 respectively.

Table 4.9 Summary of the Cronbach Coefficient Alpha for the Variables of Sections of the SP

SP Variables	Alpha	SP Variables	Alpha
Items 1-8	0.76416	Items 75-84	0.679059
Items 9-17	0.718299	Items 85-91	0.613773
Items 18-28	0.65226	Items 92-95	0.570404
Items 29-46	0.81147	Items 96-99	0.535083
Items 47-53	0.707572	Items100-116	0.88156
Items 54-65	0.922545	Items 117-122	0.708806
Items 66-74	0.861622	Items 123-125	0.385411

Sections of items with low Alpha Value

Table 4.10 Summary of the Cronbach Coefficient Alpha for the Variables of Sections of the SPSC

SPSC variable	Alpha
Items 1- 10	0.837906
Items 11-21	0.701041
Items 22-35	0.787983
Items 35-47	0.774384
Items 48-62	0.819508

4.5.5 Conclusion

The general internal consistency of the items (variables) of the SP in this set of data ranged from acceptable (alpha = 0.7) to low (alpha = 0.38). The value of alpha decreased when the number of items (variables) per section decreased, as was observed in sections 10, 11 and 14 of the SP.[79]

The SPSC generally revealed high internal consistency reliability for this set of data, as the alpha value of the variables in the sections ranged from 0.7 to 0.83. This implied a good general consistency in responses and reliability of the data.

It must be emphasised that the analysis of individual items is not encouraged and, therefore, the researcher did not attach much value to individual items that did not correlate with the total. This was to prevent over-analysis of the data, as single item reliabilities are generally very low and might lead to the scenario described as seeking a needle in a haystack when attempting to explain singular low correlations.

The SP and SPSC were subjected to factor analysis during development to assess dimensionality and it was not the aim of the researcher to assess dimensionality of the data set when computing a Cronbach Coefficient Alpha.[80]

Summaries of the Cronbach Coefficient Alpha of the 14 sections of the SP and the five sections of the SPSC were given in Table 4.9 and Table 4.10

4.6 CLINICAL ANALYSES

4.6.1 Introduction to Clinical Analyses

It was decided to conduct a clinical analysis of the sample to firstly explore the demography of the sample in terms of age and gender and percentage distribution of types of Developmental Dyspraxia. Statistical analysis results also emphasised the need to examine the data set in terms of percentage distribution of types of dyspraxia compared to SUR and SOR when subjects with Sensory Modulation Disorder (SMD) in the sample were isolated from those without.

This analysis was also conducted as a result of satisfactory internal consistency (alpha values) of the data set of the SP and SPSC to extract information that could provide valuable suggestions for future research.

The intention was also to provide a different approach to, as well as examine a different dimension of the research results. This aimed to add value to the study and lay the groundwork for recommendations for subsequent research.

Clinical analyses include analysis of the following:

- Sample in terms of age and gender
- Distribution of types of dyspraxia in sample

- Percentage distribution of types of dyspraxia in the sample with SUR and SOR

4.6.2 Clinical Analysis of the Sample

4.6.2.1 Analysis of Sample in terms of Age and Gender

Clinical analysis of the sample in terms of age and gender is depicted in Figure 4.2.

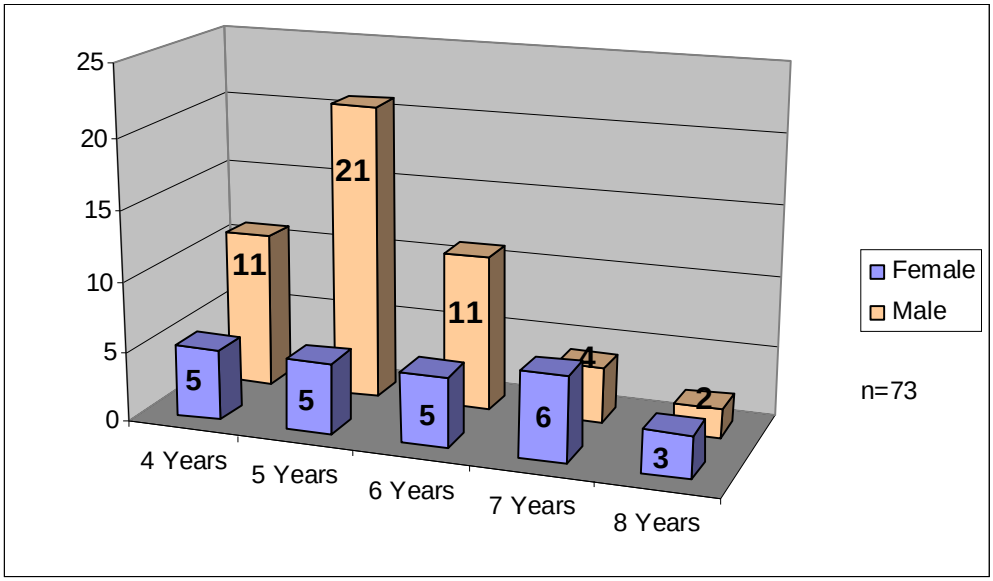

Figure 4.2 Representation of Gender and Age in Sample

The sample consisted of 73 children. Figure 4.2 gives a depiction of the gender and age distribution of the sample. As can be seen the sample consisted predominantly out of males, with the largest number in the age group five years. The largest number of females was represented in the age group seven years.

4.6.2.2 Analysis of Sample in terms of Types of Dyspraxia

As can be seen in Figure 4.3, in the sample visio- and somatodyspraxia (39%) was in the majority, with a BIS deficit second (26%), followed by dyspraxia on verbal command (25%) and generalised SI dysfunction last (10%).

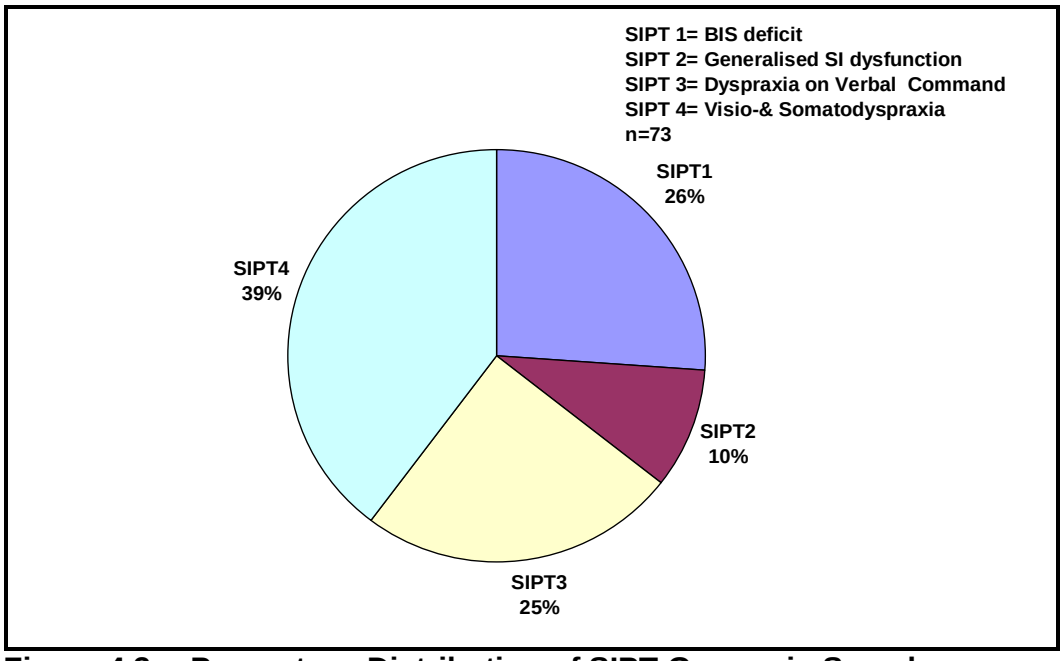

Figure 4.3 Percentage Distribution of SIPT Groups in Sample

4.6.2.3 Analysis of Sample with SUR and SOR

The fact that statistical analysis did not render consistent correlations between Developmental Dyspraxia and sensory responsivity prompted the analysis of the set of data of those subjects with SUR and SOR. This was done to look at the distribution of types of dyspraxia in the sample with SMD.

Results are given in the following order:

- Distribution of SIPT groups in sample with SMD in terms of quadrant scores on the SP (Refer to Figure 4.4)
- Distribution of SIPT groups in sample with SMD in terms of quadrant scores on the SPSC (Refer to Figure 4.5)

- Distribution of SIPT groups in sample with SMD in terms of SUR and SOR of the SP and SPSC (Refer to Figure 4.6)
- Distribution of SIPT groups in sample with SOR and SUR on the SP (Refer to Figure 4.7)
- Distribution of SIPT groups in sample with SOR and SUR on the SPSC (Refer to Figure 4.8)

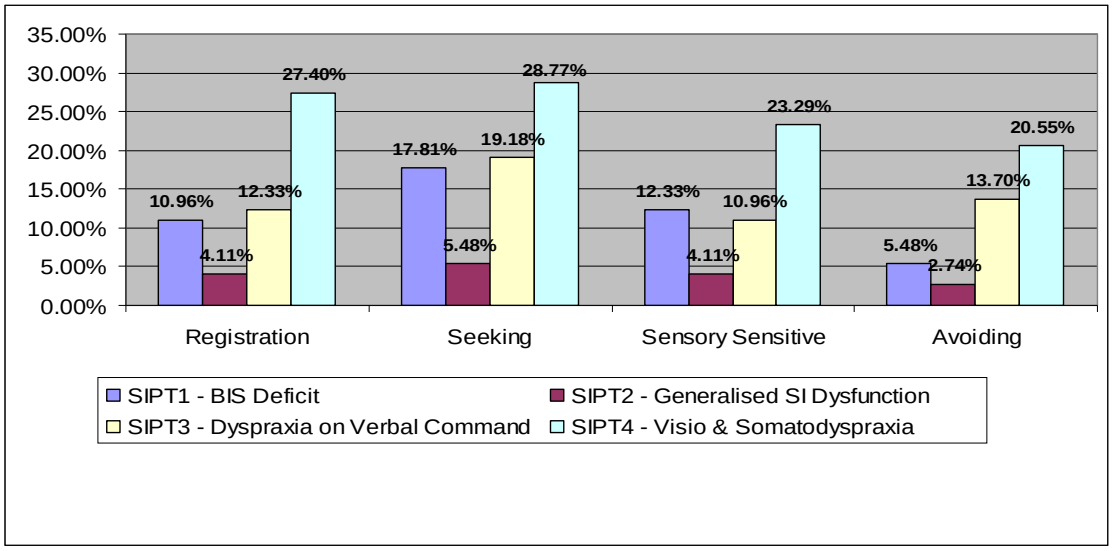

Figure 4.4 Percentage Representation of SIPT Groups in Sample with SMD in terms of the Four Quadrants of the SP

The following was observed in Figure 4.4:

- In the sample with SMD, visio- and somatodyspraxia had the greatest percentage representation in all four quadrants.
- The quadrants registration, seeking and avoiding had the second largest percentage representation of dyspraxia on verbal command.
- BIS deficit had the second largest percentage representation in the sensory sensitive quadrant.
- Generalised SI dysfunction had the smallest percentage representation in all four quadrants.
- On the SP, the seeking quadrant had the highest representation of all SIPT groups.

- This depiction of the data set in the sample with SMD differed from the total distribution of types of dyspraxia in the sample (Figure 4.3), since BIS deficit did not have the second largest percentage representation in this depiction.

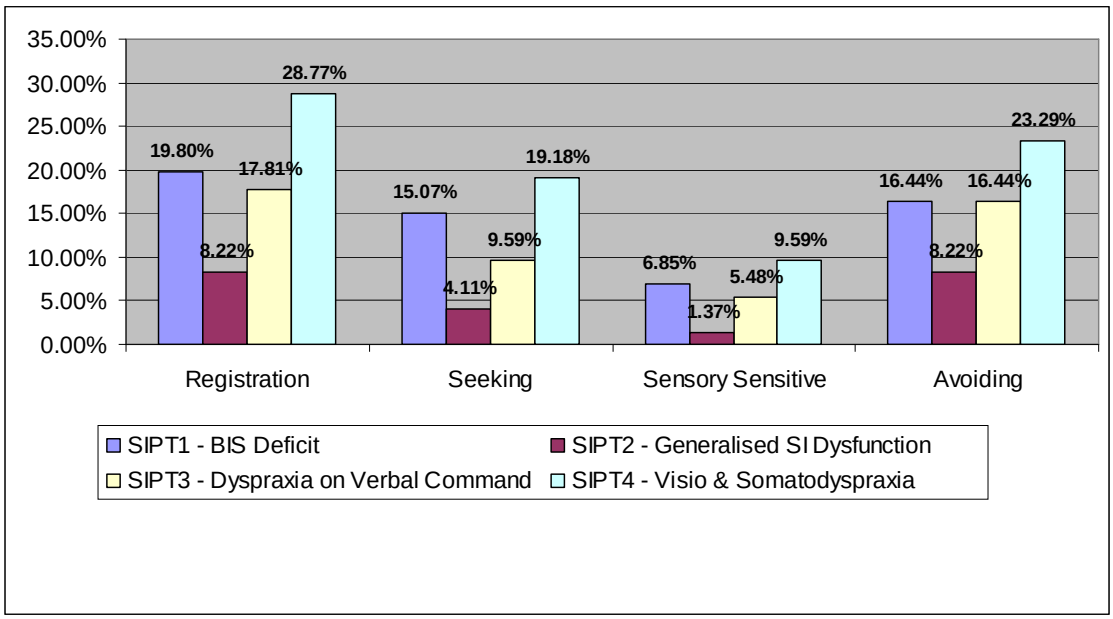

Figure 4.5 Percentage Representation of SIPT Groups in Sample with SMD in terms of the Four Quadrants on the SPSC

The following was observed from Figure 4.5

- Visio- and somatodyspraxia had the largest percentage representation in all quadrants of the sample with SMD of the SPSC.
- BIS deficit had the second largest representation in all four quadrants.
- Dyspraxia on verbal command had the third largest percentage representation in all four quadrants, followed by generalised SI dysfunction.
- The sensory sensitive quadrant had the lowest representation of SIPT groups, with the registration quadrant having the highest representation.

SIPT group representations differed between the SP and SPSC, with the highest representation on the seeking quadrant of the SP and the highest representation on registration quadrant of the SPSC. Both quadrants combined represented SUR. This phenomenon may be due to the following factors:

- The child's behaviour differs between the classroom and home.
- Children with SOR who are in "shutdown" may be perceived as having poor registration in a classroom situation which is a high intensity multi-sensory environment.
- Seeking behaviour is curtailed in the classroom where there is more structure and where boundaries are clearly defined.
- Caregivers do no view seeking behaviour as a negative attribute in children and may favour responses on the SP that represent seeking behaviour.

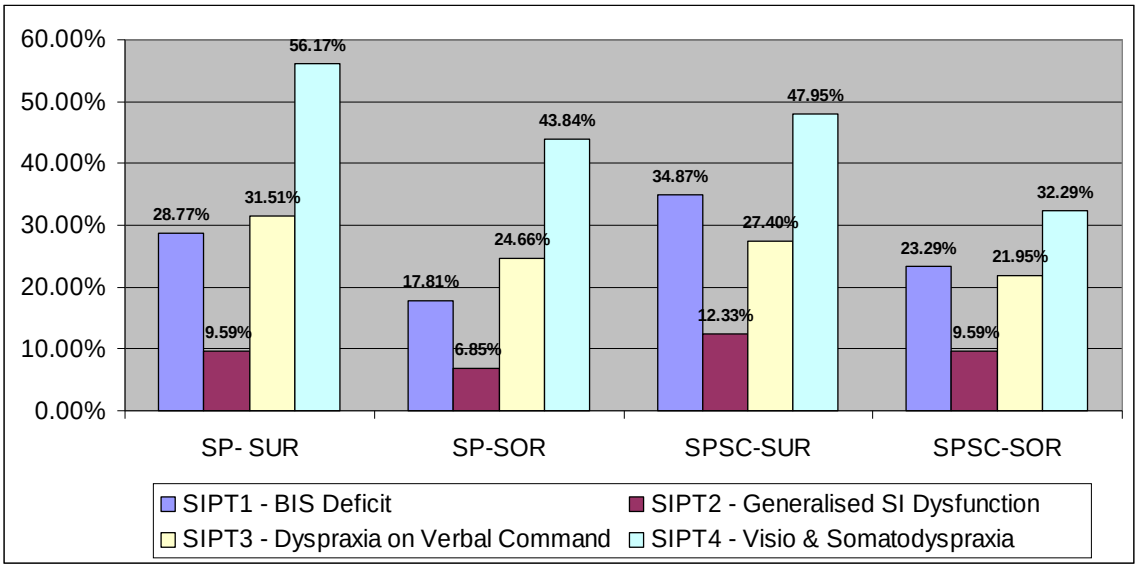

Figure 4.6 Percentage Representation of SIPT groups in Sample with SMD in SOR and SUR of the SP and SPSC

In Figure 4.6 the SP and SPSC are both represented in terms of SOR and SUR. The following was observed:

- Visio- and somatodyspraxia had the highest representation in SUR of both the SP and SPSC. It also had the highest representation of all SIPT groups in SOR of the SP and SPSC.
- Dyspraxia on verbal command had second highest representation in SUR and SOR of the SP, while BIS deficit had second highest representation in SUR and SOR of the SPSC.
- Generalised SI dysfunction had a higher representation in SUR of both the SP and SPSC than in SOR.
- Of interest was the fact that dyspraxia on verbal command had a higher representation in SUR of the SP than the SPSC, specifically as the inability to follow verbal instructions in the class should be noticed by a teacher as major contributor to inefficient task performance.

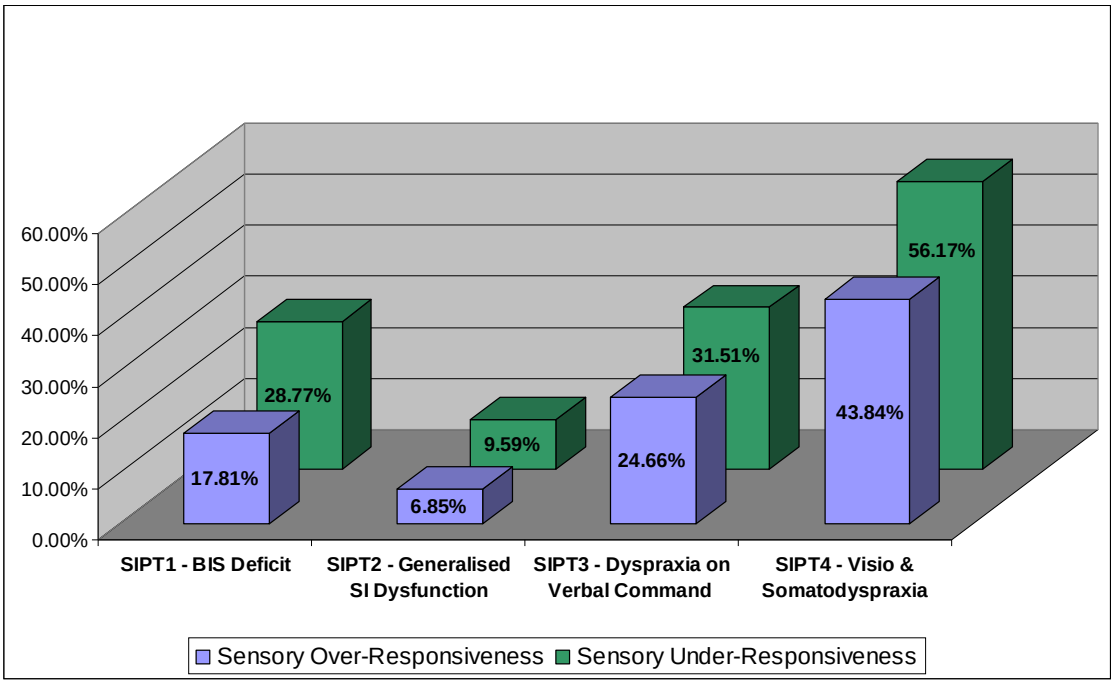

Figure 4.7 Depiction of Percentage Incidence of SIPT Groups in Relation to SUR and SOR on the SP

In Figure 4.7 percentage representations of SIPT groups in relation to SOR and SUR are given. The following were observed from this depiction:

- There was a higher representation of SIPT groups in the SUR group.
- Visio- and somatodyspraxia had the highest representation, followed by dyspraxia on verbal command, a BIS deficit and lastly generalised SI dysfunction.
- Generalised SI dysfunction had a lower representation in the SOR sample than in the SUR sample, but with a small difference between the two.

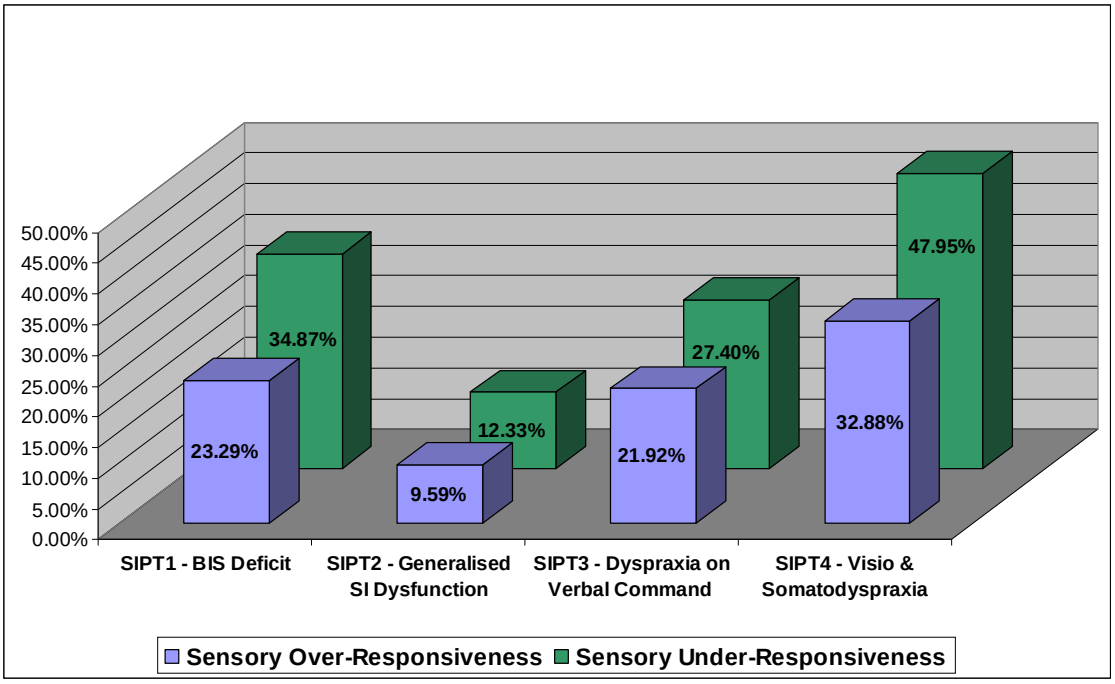

Figure 4.8 Depiction of Percentage Incidence of SIPT Groups in Relation to SUR and SOR on the SPSC

In Figure 4.8 the percentage representation of SIPT groups in relation to SUR and SOR is given. The following observations were made:

- SUR had the highest association with SIPT groups.
- Visio- and somatodyspraxia had the highest representation, followed by a BIS deficit, dyspraxia on verbal command and, lastly, generalised SI dysfunction.
- Generalised SI dysfunction had a lower representation in the SOR sample than in the SUR sample.

4.6.3 Conclusion

On both the SP and SPSC, SUR had a higher representation in the SIPT groups in the clinical analysis of the data set. In the statistical analysis there was consistently a negative correlation between SOR and SIPT groups in the few correlations that were observed. This gave rise to the question: Could the observation of a weak inverse relationship between SOR and SIPT groups from statistical analysis be supportive of a higher representation of SIPT groups in SUR from the clinical analysis?

Another interesting observation of a difference between clinical analysis and statistical analysis of data was that generalised SI dysfunction correlated positively with SOR on statistical analysis, but had a higher representation in SUR with clinical analysis. This meant that when viewing the spread of types of dyspraxia in a sample with SUR and SOR there was a higher incidence of generalised SI dysfunction in the group with SUR than the group with generalised SI dysfunction and a positive relationship with SOR.

4.7 SUMMARY

In this chapter the research results for the research aim and objectives were given. The results from statistical analysis for the research aim produced three weak negative correlations between Developmental Dyspraxia (SIPT groups) and sensory responsiveness (quadrant scores of the SP and SPSC). The three weak negative correlations were between SIPT group 1 and quadrant 3 of the SP and between SIPT groups 1 and 2 and quadrant 4 of the SPSC.

The results for Objectives 1 and 2 also produced a number of weak negative correlations and one weak positive correlation. These results are summarised in Table 4.11 for easy reference. As can be seen there were a number of weak negative correlations, of which some were significant. Only one weak positive

correlation between vestibular SOR and a generalised SI dysfunction was found. These correlations will be discussed in more detail in Chapter 5.

Table 4.11 Summary of Correlations between SIPT Groups, SUR, SOR, Quadrants and Sensory Systems of the SP and SPSC

OBJECTIVE 1: Relation between Developmental Dyspraxia and SUR and SOR		
SP : SUR	SIPT 1: BIS deficit	r = -0.208 p = 0.076
SP: SOR	SIPT 1: BIS deficit	R = -0.205 p = 0.08
SP&SPSC: SOR	SIPT 1: BIS deficit	r = -0.023 p = 0.041
OBJECTIVE 2 a: Relation between types of dyspraxia and SUR and SOR of sensory systems		
SP (auditory) SUR	SIPT 4: Visio- and somatodyspraxia	r = -0.246 p = 0.035
SP (touch) SOR	SIPT 1: BIS deficit	r = -0.217 p = 0.064
SPSC (auditory) SOR	SIPT 1: BIS deficit	r = -0.249 p = 0.033
	SIPT 3: Dyspraxia on verbal command	r = -0.231 p = 0.049
	SIPT 4: Visio- and somatodyspraxia	r = -0.228 p = 0.051
SPSC (movement) SOR	SIPT 1: BIS deficit	r = -0.233 p = 0.046
	SIPT 2: Generalised SI dysfunction	r = 0.228 p = 0.051
SPSC (touch) SOR	SIPT 1: BIS deficit	r = -0.206 p = 0.079

OBJECTIVE 2b: Relation between types of dyspraxia and sensory systems		
SP (auditory)	SIPT 1: BIS deficit	r = 0.200 p = 0.089
	SIPT 4: Visio- and somatodyspraxia	r = -0.225 p = 0.054
SPSC (auditory)	SIPT 1: BIS deficit	r = -0.226 p = 0.053

The data analysis for Objective 3 was adapted to accommodate a different approach to the third objective. This alteration was suggested in the light of inconsistent and weak correlations reported with analysis of quadrant scores and section scores of the SP and SPSC. It was recommended that the items of the SP and SPSC be analysed for internal consistency reliability. Results showed good internal consistency of the data from the SPSC, but varying alpha values for items of sections of the SP. These variations in alpha value of the SP as well the variables (items) with low correlation to the total will be briefly discussed in Chapter 5.

Clinical analysis of the sample with SMD produced interesting observations. The representation of the SIPT groups was highest in the quadrants that represented SUR on both the SP (seeking) and the SPSC (registration). Visio- and somatodyspraxia consistently had the highest representation of the SIPT groups. The SIPT groups also had the highest representation in the SUR section of both the SP and SPSC, correlating with the quadrant analysis previously mentioned. The distribution of the SIPT groups varied with BIS deficit and dyspraxia on verbal command, alternately ranking second and third. Generalised SI dysfunction had the lowest representation in all four quadrants of both the SP and SPSC.

To conclude, the results from statistical analysis were inconsistent to support a significant relation between Developmental Dyspraxia and Sensory Responsivity.

Some weak negative correlations were found with SIPT groups of which a BIS deficit featured most followed by visio- and somatodyspraxia. These correlations were isolated and, as mentioned, weak, with the majority being negative correlations.

In Chapter 5 the results of this study will be discussed and interpreted in relation to the research aim and objectives. Results of clinical analysis will be discussed, related to the discussion of statistical analysis and related to the conclusion and recommendations. A final conclusion will be made and recommendations in lieu of future research will be offered.

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

In this chapter the results of this research study will be handled by summarising the findings. This will be done by, firstly, re-orientating the reader to the research question, secondly, by reviewing the results of the statistical analysis and, thirdly, by summarising results of the clinical analyses.

A conclusion will be drawn taking into consideration both statistical results and clinical analysis. The conclusion will be followed by a discussion of problems that may have contributed to the research outcome. The limitations of this study as well as methodology will be considered under discussion of problems.

Further, a summary of contributions will be given by contemplating the implications of the research outcome. The research implications will be dissected to determine what deductions can be made, what new questions arise as a result, and to what an extent the research aim was accomplished.

The recommendations regarding suggestions for future research will be made. Recommendations will also be made in terms of the direction of future studies, taking into consideration the research result. These recommendations will specifically aim to direct focus to specific areas of Developmental Dyspraxia and Sensory Responsivity while considering methodology.

5.2. SUMMARY OF FINDINGS OF STATISTICAL ANALYSES

5.2.1 Pre-amble to Findings

This research study originated from a research question. The research question evolved from existing empirical evidence[50] linking Developmental Dyspraxia to poor sensory discrimination. The relation between Developmental Dyspraxia and sensory discrimination was confirmed through extensive factor and cluster analysis of the SIPT.[50] Knowledge of this relation prompted the researcher to question the link between Developmental Dyspraxia and sensory responsiveness.

Clinical observation of Developmental Dyspraxia and deficient sensory responsiveness occurring simultaneously led to the hypothesis that Sensory Responsivity and Developmental Dyspraxia are related. This hypothesis was based on the proposed relation of the processes of dyspraxia with information processing, which was discussed in Section 1.2. Information processing proposes stimulus identification (sensory detection) as the beginning point of planning an action. It then makes use of feedback and feed-forward (sensory discrimination) to change and adapt a motor plan for or during execution. It is on this premise that the research question has been formulated.

The aim of this study is thus a direct product of the research question that endeavoured to determine if a relationship existed between Developmental Dyspraxia and Sensory Responsivity. The method used to ascertain if such a relationship existed involved measurement instruments that identified types of Developmental Dyspraxia and measurement instruments that identified Sensory Modulation Dysfunction (sensory responsivity).

Data obtained from these measurement instruments were statistically analysed to observe if there was evidence that supports a relationship. The results of

statistical analyses were given in detail in Chapter 4. The main gist of the results pertaining to the research aim and objectives will be summarised and discussed in the following sections.

5.2.2 Summary of Findings Pertaining to the Research Aim

The results pertaining to the research aim revealed three weak correlations out of a possible 32 between quadrant scores of the SP and SPSC and SIPT groups. These weak correlations are summarised and explained as follows:

- Two weak negative correlations between bilateral integration and sequencing (BIS) deficit and sensory over-responsivity (SOR) (sensory sensitivity and sensation avoiding). These inverse correlations implied that with a BIS deficit there was less of a tendency to present with SOR. Thus, some children with a BIS deficit will be less likely to have SOR. Due to a limited number (two) of correlations with the quadrants that represent SOR, it is risky to generalise this statement, but in some cases with a BIS deficit there could be a decreased tendency to present with SOR of the sensory systems. Poor sensory discrimination would not be the result of an increased arousal state due to detecting too much information (SOR) that prevents the child from allocating attention and using feedback appropriately during motor learning.
- One weak positive correlation between generalised sensory integrative (SI) dysfunction and sensation avoiding (SOR). This implied that with a generalised SI dysfunction there was a tendency to present with SOR. In this case, caution should be used to generalise this single correlation as it, again, did not represent the all the quadrants that reflect SOR. The interpretation could be that in some cases of generalised SI dysfunction, a number of children may have experienced difficulty with discrimination of sensory information due to an over-aroused central nervous system, where they paid attention to incoming sensations more frequently and with

greater intensity or where they avoided exposure to sensory experiences. Over-responsiveness of the tactile and auditory systems are considered to be most common and, as such, could impact significantly on sensory discrimination that could, in turn, affect the ideation phase of praxis.[44] Generalised SI dysfunction means that a child has weak scores on all praxis tests and it was found that children with sensory over-responsivity also presented with motor problems such as in-coordination.[44] Thus, the correlation between SOR and generalised SI dysfunction (SIPT 2) could be worth investigating in future studies.

- Two SIPT groups that correlated with sensory responsivity were BIS deficit and generalised SI dysfunction and the quadrants represented in the correlations were sensation avoiding and sensory sensitive, which represent the sensory over-responsive range.

5.2.3 Summary of Findings of Research Objective 1

The correlations between sensory under-responsivity (SUR) and SOR and SIPT groups were again inconsistent in terms of numbers. Only three weak negative correlations were revealed out of a possible 24. These were:

- An inverse correlation between SUR and a BIS deficit. The implication could be that, in some instances, where a BIS deficit was present SUR was less likely to be present. Caution should be taken against generalising this result. If there was less of a tendency of SUR, then it would mean that in some instances of a BIS deficit there would be less tendency for an under-aroused central nervous system to impact on sensory detection and response selection that, in turn, would impede feed-forward, which is central to a BIS deficit. In this case, the problem then may have been with discrimination of sensory information after sensory detection has taken place.
- An inverse correlation between SOR and a BIS deficit. Here the relation implied that in the presence of a BIS deficit there was a smaller tendency

of poor sensory detection due to an over-aroused central nervous system as a result of SOR. The BIS deficit, again, may have been due to poor sensory discrimination rather than poor ability to orient to and detect sensory information. Poor processing (discrimination) of the vestibular and proprioceptive sensations was proposed to be the major contributor to a BIS deficit.[16]

- The combined quadrant scores of the SP and SPSC revealed a negative relation between a BIS deficit and SOR. It appeared as if, in this case, the tendency of SOR was less in the presence of a BIS deficit. Feed-forward is central to BIS, but also forms part of information processing and requires attention and the capacity to process information.[1] If SOR was present, an aspect like attention would be compromised due to an over-aroused central nervous system, in which case feed-forward would be impaired. It is thus plausible that there was less of a tendency for SOR with a BIS deficit because sensory discrimination instead of sensory modulation may have been the causative factor in a BIS deficit.
- The preceding correlations gave rise to the question as to the role of sensory responsivity versus sensory discrimination in a BIS deficit. These repeated negative correlations warrant further enquiry to determine if BIS was fundamentally caused by inefficient sensory processing (sensory discrimination) as there was no statistical correlation with SOR and SUR.

5.2.4 Summary of Findings of Research Objective 2

Sensory systems were correlated with the SIPT groups. SIPT groups were also correlated with SUR and SOR of the sensory systems of the SP and SPSC respectively. Out of a possible 72 correlations, eight weak correlations were observed between SIPT groups and SUR and SOR of sensory systems. The following correlations were observed and are grouped, as far as possible, in terms of overlap of the SP and SPSC.

- An inverse relation between a BIS deficit and SOR of the tactile systems of both the SP and SPSC. There was less tendency of SOR of the tactile system when a BIS deficit was present. An explanation for this correlation could be that there is not a confirmed relation in literature between a BIS deficit and poor tactile discrimination. Should SOR of the tactile system occur, it could result in avoidance of exposure to tactile experiences and, as such, compromise tactile discrimination. The fact that there is not a link between tactile discrimination and a BIS deficit described in literature was supported by this inverse correlation[81].
- An inverse relation between dyspraxia on verbal command and SOR of the auditory system. In the case of dyspraxia on verbal command there was less tendency of SOR of the auditory system. This scenario is plausible as it has been observed in clinical practice that SUR of the auditory system appears to occur more frequently in association with dyspraxia on verbal command. Less tendency of SOR of the auditory system will prevent avoidance of or blocking out of auditory input that can be detrimental to development of auditory skills. There would also be less tendency of not paying attention to auditory input due to over-arousal of the central nervous system.
- An inverse correlation between visio- and somatodyspraxia and SUR of the auditory system (SP). There was less tendency of under-responsiveness of the auditory system in the case of visio- and somatodyspraxia and this could have impacted positively on the child's ability to maintain the appropriate level of central nervous system arousal to detect auditory input, such as verbal instructions. Another consideration is that if ideation was not affected by auditory detection and, subsequently, language, which is central to ideation[38], then it is possible that ideation is not weak in children with visio- and somatodyspraxia and that they rather present with poor motor planning and motor execution.
- As in the preceding point, an inverse relation between visio- and somatodyspraxia and SOR of the auditory system (SPSC). The question

arose again; if there was less tendency of auditory SOR with a visio- and somatodyspraxia then auditory detection was assumed to have been sufficient to contribute positively to the ability to pay attention to verbal instructions. Does this correlation support the possibility that language and ideation is not central to visio- and and somatodyspraxia, but rather perhaps motor planning and motor execution, which is feedback and feed-forward dependent and relies on visual, vestibular, tactile and proprioceptive information?

- An inverse relation between a BIS deficit and SOR of the auditory system. Auditory SOR was less likely in the case of a BIS deficit and implied less tendency of over-arousal due to increased detection of auditory input. This correlation corresponded with other correlations in that there was a general trend of a negative correlation between a BIS deficit and SOR. This could possibly support the supposition that a BIS deficit is fundamentally associated with sensory processing rather than sensory responsivity.
- An inverse relation between a BIS deficit and vestibular SOR, which implied less tendency of vestibular SOR. Since there is a definite link between a BIS deficit and vestibular and proprioceptive processing[16], the correlation could have suggested that poor vestibular processing was not the result of avoidance of vestibular input due to SOR of the vestibular system.
- A positive relation between generalised SI dysfunction (SIPT 2) and vestibular SOR. This correlation corresponded with a correlation observed in statistical analysis of data for the research aim, where a positive correlation between SOR and generalised SI dysfunction were also observed. From these correlations it may be worthwhile to further investigate the role of SOR in a generalised SI dysfunction. SOR could be either sensory sensitivity or sensation avoidance. Were there an avoidance of exposure to sensory experiences, in this correlation specifically vestibular input, the result could be far-reaching in terms of

information processing and motor learning impacting on feed-forward and feedback. SOR could also be responsible for poor sensory detection if there was increased central nervous system arousal and decreased ability to allocate attention to incoming sensory input.

From a total of 44 possible correlations, there were three correlations between SIPT groups and sensory systems. Where possible, discussion of correlations was combined if there was overlap between the SP and SPSC:

- An inverse relation between a BIS deficit and the auditory system (SP and SPSC), thus implying that there was less tendency of poor auditory responsiveness in the presence of a BIS deficit. This correlation corresponded with a previously discussed negative correlation. The role of the auditory system, and specifically auditory responsiveness, in a BIS deficit seems to be less conspicuous and should be considered in the context of motor learning and feed-forward where vestibular and proprioceptive function is considered to be of consequence.
- An inverse relation between visio- and somatodyspraxia (SIPT 4) and auditory responsivity. There seems to be a repeated inverse relation between visio- and somatodyspraxia and auditory responsivity, which is supported by the cluster analysis of the SIPT[81] where the highest score in this clustering was dyspraxia on verbal command, and thus confirming that the auditory system has less significance in this type of dyspraxia.

5.2.5 Summary of Findings of Research Objective 3

The results of the third objective were given in Chapter 4, Section 4.5. The Cronbach Coefficient Alpha was computed on the SP and SPSC items per section to determine internal consistency reliability of the data. It was also done to report the reliability of this set of data[80] for future use, should the need arise. A

brief summary of significant information regarding the internal consistency of the SP and SPSC is given:

Sensory Profile

- The SP's alpha values varied from acceptable to a low value. The lower alpha values were due to some sections containing very few items.
- Examination of items that did not correlate with the total did not reveal a specific pattern of response or represent a specific quadrant of Dunn's model. All four quadrants of Dunn's model were represented by the items, but some items with a low correlation did not contribute to the quadrant scores.
- Standard deviations and the mean of items also did not reveal a trend or pattern that could account for items' low correlation with the total.
- Some sections that contained a lot of items and had a low alpha value displayed small standard deviations for those items, indicating little variation in responses for those items.
- It may be that the items' (not correlating with the total) phrasing contributed to the low correlation instead of the alignment of those items with quadrant of factor scores.

Sensory Profile School Companion

- The SPSC alpha values ranged from acceptable to very good. This implied a general good internal consistency.
- Of interest is the fact that items that did not correlate with the total only represented three of the four quadrants of Dunn's model and that the registration quadrant did not contain any items with a low correlation.
- The items that did not correlate with the total, again, did not display a pattern or trend of low or high means and standard deviations.
- Phrasing of statements may have elicited responses that account for a low correlation.
- Another point of interest is that there was a similar item on both the SP and SPSC that had a low correlation. It was item 8 on the SP and item 4

on the SPSC. This item represented the seeking quadrant and on both questionnaires had a low correlation.

5.3 SUMMARY OF FINDINGS OF CLINICAL ANALYSES

5.3.1 Pre-amble to Clinical Analyses

The outcome of the statistical analysis prompted clinical analysis of the data set to examine the sample in terms of the demographic characteristics, but also to provide a different angle from which to view the data. To achieve this, the sample was divided into two groups - a group with Sensory Modulation Dysfunction (SMD) and a group without. The group with SMD was examined in terms of the distribution of SIPT groups in the sample with SMD. The findings are given in three sub-sections.

Results from the clinical analysis will be compared to the summary of findings of the statistical analysis and used to validate the need for the study in subsequent sections of this chapter.

5.3.2 Sample

The sample consisted of predominantly males, with the highest representation in the age group five years. Out of 73 subjects in the sample, 49 were male and 24 female. The highest number of females was in the age group seven years.

The distribution of types of Developmental Dyspraxia in the entire sample was as follows:

- Visio- and somatodyspraxia: 39%
- BIS deficit: 26%
- Dyspraxia on verbal command: 25%

- Generalised SI dysfunction: 10%

5.3.3 Distribution of SIPT Groups in SP and SPSC Quadrants

- The SP had the highest representation of SIPT groups in the seeking quadrant, with visio- and somatodyspraxia (SIPT 4) being the highest representation in all four quadrants.
- Dyspraxia on verbal command had the second highest representation in three quadrants of the SP, except in the sensitive quadrant. BIS deficit had the second highest representation in this quadrant.
- The SPSC had the highest representation of SIPT groups in the registration quadrant with visio- and somatodyspraxia, again, the best represented in all four quadrants of the SPSC.
- BIS deficit had the second highest representation in all four quadrants of the SPSC. It appears as if tasks requiring bilateral function have high priority in the classroom. This observation was against expectation, where the researcher anticipated that dyspraxia on verbal command would feature more prominently on the SPSC due to the demands formal learning places on the ability to follow instructions.
- Review of the sample, however, placed the majority of subjects (n=58) in the pre-school phase, where development of fine motor function is a priority and children are exposed to activities that require bilateral function.

5.3.4 Distribution of SIPT groups in SUR and SOR of the SP and SPSC

- SUR had the highest SIPT group representation on both the SP and SPSC. Visio- and somatodyspraxia also had the highest representation of all SIPT groups in both SUR and SOR of the SP and SPSC.

- Dyspraxia on verbal command was better represented in both SUR and SOR of the SP than a BIS deficit. This scenario was reversed on the SPSC where BIS deficit was better represented.
- Generalised SI dysfunction had the highest representation in SUR of the SPSC of all SIPT 2 representations.
- It seems as if the spread of the SIPT groups is less varied and less prone to extremes in the SPSC than in the SP. This could be due to the caregiver's subjectivity.
- SUR and the types of dyspraxia (SIPT groups) have a prominent association, as can be observed from the clinical analyses.

5.4 CONCLUSIONS

5.4.1 Conclusion of Statistical Analysis

5.4.1.1 Research Aim

This study aimed at determining if a relationship existed between Developmental Dyspraxia and Sensory Responsivity. From the analysis of the data set it can be concluded that results did not produce evidence that supported a consistent and significant positive relationship.

5.4.1.2 Research Objectives 1 and 2

Some weak negative and individual weak positive correlations were observed between types of Developmental Dyspraxia and SOR, SUR and sensory systems. Closer scrutiny of these weak correlations revealed interesting relations, some of which are supported in Sensory Integration literature[81] and substantiate the need for further research in this area.

The weak correlations that were observed led to the following conclusions:

The weak positive relation between generalised SI dysfunction and SOR justifies further investigation into the role SOR plays in a child's ability to effectively and accurately discriminate sensation for use. Sensation-avoiding behaviour or sensitivity may, in this group, lead to 'shutdown' which impedes the ability to detect and discriminate sensory information. Children with SOR and generalised SI dysfunction will possibly have severe dysfunction[81]. The vestibular system was implicated in this relation. Avoidance of vestibular sensation or 'shutdown' after vestibular input could contribute to problems with feed-forward[16] and also detection of vestibular input. The processes of praxis that are implicated are ideation and motor planning and, subsequently, motor execution.

A BIS deficit had the majority of negative correlations with sensory systems and SOR of those systems. There was one correlation with SUR and four correlations with SOR. The role of sensory responsivity in BIS deficits is thus questioned. The role of sensory responsivity could be purely incidental, which will then point to a concomitant association where the one occurs in the presence of the other. It is possible that sensory discrimination is the primary basis for BIS deficits and that there is a breakdown of vestibular and proprioceptive processing after stimulus detection. The amount or intensity of the sensory input does not contribute to the effective processing of that input. The breakdown would then be at the feed-forward and feedback level of information processing and consequently impact on the motor planning and motor execution level of praxis.

The weak inverse relation between visio- and somatodyspraxia and auditory function confirms that the detection of auditory input in this type of Developmental Dyspraxia is not problematic. It is in agreement with factor analysis of the SIPT, where praxis on verbal command is the highest SIPT score in this group that indicate dysfunction. Even though auditory detection may not be a problem with this type of dyspraxia, caution should be used against assuming that language will be good. Poor ideation in visio- and

somatodyspraxia is presumably not the result of poor language, as language is a cortical function.[38] The inverse relation between auditory function and visio- and somatodyspraxia is thus supportive of the possibility that poor ideation is caused by factors other than poor auditory detection, which could impact on auditory processing and subsequently on language.

Dyspraxia on verbal command had a weak inverse relationship with SOR of the auditory system. Inadequate detection of auditory input does not seem to be due to SOR and subsequent avoidance or 'shutdown' during exposure to auditory stimuli. Praxis on verbal command is the SIPT test that has a correlation with dyspraxia on verbal command.[81] Poor praxis on verbal command is proposed not to be the result of detecting too much auditory input, which could in turn impede processing.

5.4.1.3 Research Objective 3

The alpha values of the items of sections of the SP varied between acceptable to low alpha values. Internal consistency reliability thus varied due to some sections that consisted out of few items. There was generally good internal consistency of the SPSC items. Overall, it can be concluded that the data set of the SP and SPSC had fair to good internal consistency reliability, with slightly more variation of the SP.

5.4.2 Conclusion of Clinical Analysis

The sample with SMD was analysed to examine the prevalence of Developmental Dyspraxia in this sample. The SP and SPSC were analysed separately. The following can be concluded:

- The registration quadrant of the SPSC had the highest representation of types of Developmental Dyspraxia, which points to a more pronounced possibility of an association.
- The seeking quadrant of the SP had the highest representation of types of Developmental Dyspraxia, which also points to a higher probability of an association.
- SUR on both the SP and SPSC had a higher representation of types of Developmental Dyspraxia.

It seems as if SUR has a more pronounced and closer link with Developmental Dyspraxia than SOR. The researcher's initial hypothesis for this research study was that SUR has an influential association with Developmental Dyspraxia. Clinical analysis of the sample with SMD thus argues support for this notion and to look at alternative methods and approaches to examine this link.

Another conclusion from clinical analysis is that visio- and somatodyspraxia has the highest representation of all types of Developmental Dyspraxia. In the sample with SMD it is likely that the most common type of dyspraxia encountered will be visio- and somatodyspraxia. The high prevalence of this type of dyspraxia in a sample with SUR also questions the influence SUR has on the processing of sensory information.

Contrasts between the SP and SPSC clinical analysis results are most probably due to differences in environment, expectations and values that guide decision-making when choosing responses. This is particularly evident when viewing quadrants of the SP and SPSC. On the SP, the seeking and registration quadrants have the highest representation, as opposed to the SPSC where the registration and sensation avoiding quadrants have the highest representation.

The clinical analysis offers a different approach to the interpretation of the research data and highlights some interesting points that are in agreement with

some of the statistical analysis results. These points will be discussed in the following section.

5.4.3 Conclusion Incorporating Statistical and Clinical Analysis

SUR had highest representation in the clinical analysis of the sample with SMD and types of Developmental Dyspraxia on both the SP and SPSC. This is in contrast to the weak inverse correlation between mostly SOR and types of Developmental Dyspraxia. It is argued that if one analysis supports the probability of an association (SUR and dyspraxia) and another indicates less likelihood of a relation (SOR and dyspraxia), that the two forms of analyses validate a relation on opposite ends of a continuum.

Visio- and somatodyspraxia and dyspraxia on verbal command are the two dyspraxias that warrant further investigation into the relation with SUR when taking statistical and clinical analysis into account.

There is a contradiction in results from clinical analysis and statistical analysis as to the relation between generalised SI dysfunction and SUR or SOR. Statistical analysis revealed a positive relation between generalised SI dysfunction and SOR, but clinical analysis shows that generalised SI dysfunction has a higher representation in SUR. In this case, SOR may be mistaken for SUR if a child is in ‘shutdown’ and blocking out sensory input due to over-responsiveness as opposed to not detecting sensory input.

BIS deficit had the most inverse relations with SOR, but displayed a higher representation in SUR on both the SP and SPSC. It gives rise to the question whether both analyses support an association of some kind between BIS deficits and SUR. Seeking behaviour, which is a quadrant of SUR, may, for instance, interfere with the ability to pay attention to incoming vestibular input, or registration (quadrant of SUR) may impede detection of important proprioceptive

input. If the relationship between SUR and a BIS deficit is concomitant then SUR may impede sensory processing as a result of fluctuating CNS arousal levels. This is because registration represents an under-activated CNS as opposed to seeking behaviour, which may lead to over-activation of the CNS.

5.4.4 Final Conclusion

The results from this set of data do not offer evidence of a consistent and unambiguous relationship between Developmental Dyspraxia and Sensory Responsivity. However, some singular weak inverse and positive relations were observed which led to some interesting interpretations that were also supported and validated by clinical analyses of data.

The role of SUR in Developmental Dyspraxia is highlighted, and specifically with respect to visio- and somatodyspraxia and dyspraxia on verbal command. The auditory system, in particular, has an affiliation with these two types of dyspraxia.

SOR and the relation with generalised SI dysfunction also attracted attention and warrants some further investigation. The link with the vestibular system was observed in this relation and the possible effect on feed-forward as well as the probability that this type of dyspraxia, in association with SOR, may compound the severity of the dysfunction.

BIS deficits had inverse relations with predominantly SOR of three sensory systems, namely touch, auditory and vestibular. A smaller tendency of SOR in association with BIS deficits gives rise to the question: Do the clinical analyses that reveal a higher presence of BIS deficits in the SUR sample support a concomitant relationship with SUR, and are BIS deficits fundamentally caused by poor processing of vestibular and proprioceptive input?

The fact that there were predominantly inverse relations between SOR and SIPT groups led to the question whether SOR is not a condition that can occur as a sole diagnosis.[44] Visio- and somatodyspraxia's inverse relation with the auditory system is validated by the low correlation between praxis on verbal command (SIPT) and visio- and somatodyspraxia, as seen in factor analysis of the SIPT. This inverse relation confirms that the auditory system is less likely to play a role in this type of dyspraxia. The fact that ideation is poor in visio- and somatodyspraxia leads to the researcher querying the role that language plays in ideation in this instance.

5.5 DISCUSSION OF PROBLEMS

In this study the research results validate a comprehensive evaluation of factors that could possibly have contributed to the research outcome. These factors are:

- Measurement instruments
- Procedures, namely data analysis and timeframe

5.5.1 Measurement Instruments: SP and SPSC

The SIPT, SP and SPSC were used in this study. Their reliability, validity and suitability have been discussed in previous sections. The use of the SIPT and SP to measure change, report on discriminant validity, report on differences in populations and to support construct validity is widely reported in occupational therapy literature.[22,23,50,58,69,70]

The use of the SP and SPSC in combination with the SIPT to determine if a relationship existed presented with some challenges in terms of data collection. Although every precaution was taken to ensure compliance on every level of the data collection phase, some discrepancies were noted in terms of the responses

of caregivers. This is illustrated in Figure 5.1, where the response tendencies of caregivers were compared to those of teachers in terms of a mean.

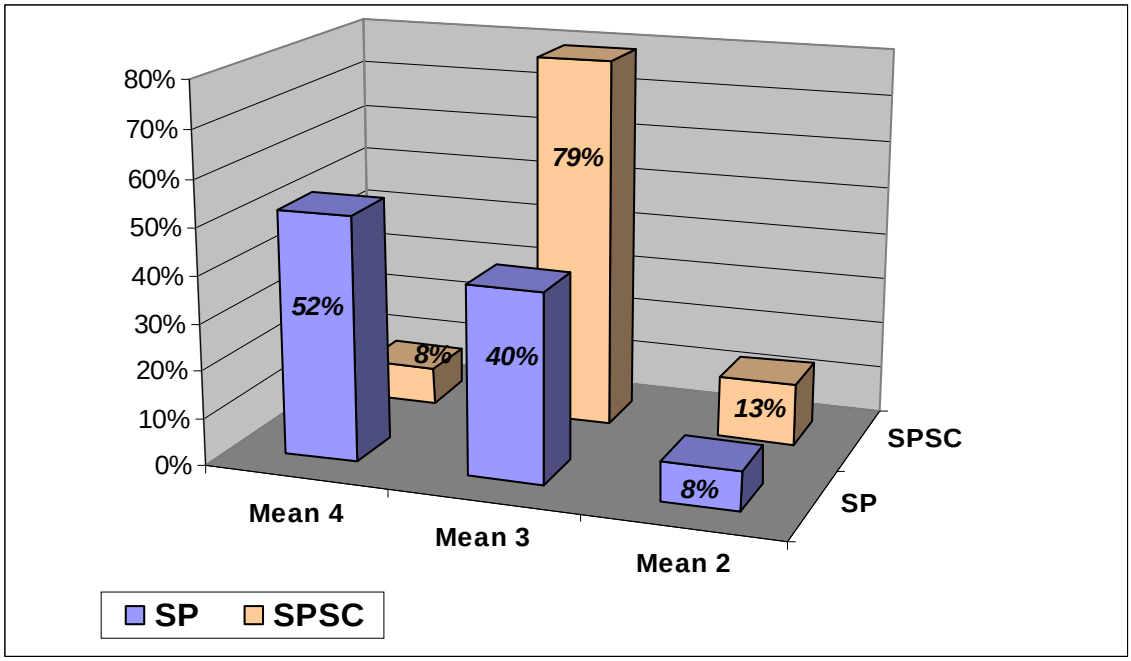

Figure 5.1 Percentage Representation of Mean Responses of Teachers and Caregivers on the SP and SPSC

The following differences are observable in the responses of caregivers and teachers:

- The highest percentage responses on the SP was in the 'never to seldom' response category (mean = 4).
- The second highest percentage response category on the SP, with a mean of 3, was 'occasionally and frequently'.
- The response categories of 'always and frequently' (mean = 2) had the lowest representation on the SP.
- In contrast, the responses 'frequently and occasionally' (mean = 3) have the highest representation on the SPSC and the responses 'almost never to seldom' (mean = 4) the lowest percentage representation.

Figure 5.1 therefore illustrates the contrasting way in which caregivers and teachers responded to items of the SP and SPSC.

The Cronbach Coefficient Alpha that was computed on items of the SP and SPSC links with this discussion. The alpha value of the SP items varied in-between sections ranging from acceptable to low in some sections. The amount of items with a low correlation with the entire test affected the alpha values of a section as did the amount of items per section.

The SPSC had an acceptable to good alpha value across the whole test. The tendency of caregivers to pick a 'seldom' or 'never' response on the SP warrants discussion as to the reasons why and if this tendency contributed to the variation in the alpha values for items of the SP.

Possible reasons for selecting 'never' or 'seldom' are:

- Some statements of behaviour (items) are very rarely observed at home as there is not enough opportunity to observe it. This may be due to time constraints.
- The caregiver does not have insight into the behaviour and therefore chooses the least "harmful" option which is 'seldom' or 'never'.
- The caregiver is unsure about the meaning of the statement.
- The caregiver's interpretation of a question is literal as opposed to viewing a statement as a tendency. For instance, the statement 'seems to have weak muscles' refers to a general tendency of poor muscle strength and not pathology, but can elicit a 'never' response if viewed as pathology.
- Some behaviours that are observed 'infrequently' are atypical and should be reported as being observed as 'never' due to the fact that they occur infrequently.
- Some behaviours that constitute a problem are viewed as 'typical' by the caregiver and are therefore not considered a problem.

Relevant to the above is that parent report methods such as the SP may be prone to inherent subjective biases as well as restrictions in the number and type of questions included.[82] Another factor or limitation to parent report methods is the fact that a caregiver or parent can adapt to their child's sensory processing problems and thus influence the number and quality of shared experiences in either a positive or negative way.[82] This ability to adapt will enhance or impede engagement in daily routines and subsequently influence responses on parent report measurements.

According to the alpha values of items of the SP and SPSC and the analysis of response tendencies of caregivers and teachers, the set of data from the SPSC has better internal consistency. This is supported by the fact that there were more correlations between the SIPT and the SPSC than between the SIPT and the SP.

Clinical analysis also highlighted an interesting point: the 'registration' quadrant of the SPSC had the highest percentage representation of the four SIPT groups (Figure 4.5). The computation of the Cronbach Coefficient Alpha on the SPSC showed that no items that represent 'registration' on the SPSC had a low correlation with the total. Thus, the items representing the 'registration' quadrant of the SPSC had a good correlation with the total and have good internal consistency.

To conclude, the variation in responses between caregivers and teachers due to subjective biases as well as variance in alpha values could have contributed to the research outcome in terms of the relation between Developmental Dyspraxia and Sensory Responsivity measured with the SP.

5.5.2 Measurement Instruments: the SIPT

The SIPT is widely used worldwide and recognised as a reliable measure of Sensory Integration and Praxis. The use of the SIPT in conjunction with other measurements with the purpose to determine a relation between constructs is not well documented. Some studies are reported to demonstrate mixed results obtained from the use of the SIPT in conjunction with other measurement instruments.

A study by Parham[83] produced favourable results when SIPT factors were significantly related to reading and arithmetic achievement in a four-year longitudinal study. Parham used the SIPT and the Kaufman Assessment Battery for Children in this study. Three SIPT factor scores (praxis factor, visual perception factor and somatosensory factor) were used in the data analysis. These factor scores were used in correlation matrices of Pearson's *r* coefficient. The praxis and visual perception factor correlated closely with reading and arithmetic achievement, with the most significant being the relationship of sensory integrative measures to arithmetic achievement.

Though Parham's study produced good results, other studies delivered negative relations or limited differences. Bundy, Shia, Qi and Miller[84] investigated how play is affected by sensory processing dysfunction by correlating the scores of the Short Sensory Profile (SSP), the Test of Playfulness (ToP) and six of the seven praxis tests from the SIPT. There were statistically significant correlations between the SSP and the ToP, but a negative relation between ToP and the SIPT scores, suggesting little relationship between play and motor skills. The SIPT was also used in a study by Parush, Sohmer, Steinberg and Kaitz[85] to determine if the somatosensory tests of the SIPT can assist in differentiating tactile defensiveness in an ADHD group of boys with and without tactile defensiveness. Results indicated little to no difference in somatosensory test scores between groups, confirming that the SIPT somatosensory tests do not

discern between tactile defensiveness. Walker and Burris[86], in a study prior to that of Parham, also looked at the relationship of scores on the SIPT to scores of academic achievement (Metropolitan Achievement Test). Results rendered some correlations but with low significance and indicated no predictive relationship between scores on achievement and the SIPT.

The use of the SIPT in this study was relevant in terms of identifying types of Developmental Dyspraxia as it has good discriminant and construct validity. Through the SIPT it was not only possible to confirm the presence of Developmental Dyspraxia, but also to discern between types of dyspraxia. The use of the SIPT in conjunction with other tests, to determine relations amongst constructs, more often than not produced results that failed to support research hypotheses. It is in agreement with the results of this study and possible reasons are given in Section 5.6.1.1.

To conclude, the measurement instruments, when used individually, appear to measure what they are intended to measure. The SP has a better record of correlations with other measurement instruments[84] than the SIPT. Taking into consideration the variations of alpha values (SP) and the track history of the SIPT in studies with other measurement instruments, it is possible that the research outcome was affected by the measurement instruments and their interaction with each other.

5.5.3 Procedures: Data Analysis

Data analysis included preliminary analysis to observe for patterns or groupings of SIPT groups in specific quadrants of the SP and SPSC. When there was no observable grouping or pattern, analysis pertaining to the research aim and objectives were performed. In-depth analysis of data as it pertains to objectives was conducted. The analysis pertaining to the third objective was adjusted based on the results for the first two objectives.

The initial train of thought with this research was to examine the relations between types of dyspraxia and sensory systems. This was done in fulfilment of Objective 2. Dunn, however, states that it is important to consider not only which sensory systems are implicated, but how a person responds to stimuli. This observation was supported by factor analysis of the SP, as factor loadings did not sort by sensory systems but by the child's responsivity to sensory experiences.[61] By considering how a child responds to sensory experiences facilitates thinking about the effect of sensory over- or under-responsivity on performance in daily life.

As factor analysis identifies relationships among similarly-performing items and helps to assess dimensionality of constructs, it is viable and proper to conduct factor analysis of a set of data for this purpose. This is also recommended by Dunn and Westman[24], where they propose comparing children with various dysfunctions to identify unique patterns of performance from one dysfunction group to another, as discriminant analysis among groups might assist in identifying a number of items on the SP that could serve as a screening tool. Comparative analyses of measurement tools such as the SP and the SIPT could be useful to establish if the SP taps similar or unique factors in performance. Conducting factor analysis of data would thus be a high priority, but also correlating factor scores for the measurement instruments used.

In retrospect, the data analyses conducted in this study provided answers to questions asked and were thus relevant and appropriate. However, the wealth of information that could be uncovered from factor analysis of data from the SIPT, SP and SPSC compels the researcher to mention this as a possible problem. To achieve this, a bigger sample is required and, as such, diminishes the relevance of such an endeavour and relegates this problem to a recommendation for future research.

5.5.4 Procedures: Timeframe

This type of study requires meticulous collection of data over a period of time. To ensure a big enough sample, enough time is needed to ensure good quality data. This study was subjected to time constraints and, even though a big enough sample for the purpose of this study was achieved, a bigger sample would have been more ideal. Also, collection of data was done with the help of recruited occupational therapists who were furnished with specific instructions and guidelines in an attempt to ensure that the collection process adhered to required standards. It is the opinion of the researcher that collection of this type of data, which requires specialised and specific skills, should be done by one person to ensure quality control on all levels, but this would require more time to achieve a big enough sample size.

5.6 SUMMARY OF CONTRIBUTIONS

5.6.1 Implications of Results

When a research study is undertaken, the intention is to make a contribution to that specific area or field that is being researched. In this study the intended contribution was to provide information that could eventually enhance treatment protocols for Developmental Dyspraxia. The actual outcome turned out to be a mismatch with the expected outcome and what was intended did not come to full fruition. However, this research outcome has implications that are worth discussing, as every research study makes a contribution.

5.6.1.1 Deductions

Praxis, when viewed from Motor Learning Theory and Sensory Integration Theory,is conceptualised from an information processing and sensory processing foundation. The two processing perspectives are amalgamated to form an

encompassing continuum that includes ideation, motor planning and motor execution. This research study aimed at introducing another factor into this continuum, namely sensory detection. The results failed to support the insertion of sensory detection into this continuum. It did, however, lead to the researcher making the following deductions.

There is not substantial evidence to support relations between Developmental Dyspraxia and Sensory Responsivity. This accentuates the fact that deficient sensory responsiveness (SOR and SUR) and the link with the dyspraxia continuum is more complex. The role of sensory (stimulus) detection in stimulus identification and recognition stages requires more in depth clarification to ascertain if over- or under detection of sensory input impacts on ideation and subsequent processes. In this study the behavioural component or end-products of both praxis and sensory responsivity were assessed and compared. More in-depth analysis is required of the constructs that underlie praxis and sensory responsivity and along with comparison of those constructs. Another factor to consider is fluctuation between SOR and SUR and if that should be considered in such an analysis.

Another deduction of this study is that BIS deficits are not likely to occur in the presence of SOR. Of interest is the trend of an inverse relation to either the auditory system or auditory SOR. The other sensory systems that also had weak inverse correlations were the tactile and the vestibular systems. Conversely, the clinical analysis showed a high representation of BIS deficits in the SUR sample, which questions the contribution of SUR of sensory systems to the incidence of BIS deficits.

Auditory responsivity has an interesting and dubious association with visio- and somatodyspraxia, as auditory SOR or SUR is less likely to occur in the presence of visio- and somatodyspraxia. Because ideation is very likely to be impeded in this type of dyspraxia and ideation is closely linked to language, there is

speculation about the role of language in ideation with visio- and somatodyspraxia, particularly since praxis on verbal command is purported to be good[81] and there is not a tendency for SUR or SOR of the auditory systems. If language is not affected in this type of dyspraxia and thus does not impact on ideation, what is responsible for poor ideation and to what extent? Since there is not a confirmed link between sensory discrimination and ideation, the role of arousal should be considered as an important link in ideation. Increased arousal is proposed to accompany intention (idea)[38] and the lack thereof could thus impede ideation. This is supported by clinical analyses and the high percentage representation of visio- and somatodyspraxia in SUR (Figures 4.7 and 4.8).

The presence of SOR may be associated with a more severe form of Sensory Integration Dysfunction, like generalised SI dysfunction. This is supported by the positive correlation between generalised SI dysfunction and SOR. The implication of avoiding and blocking out sensory information appears to be more profound on development and the acquisition of skill.

The data obtained from the measurement instruments met the requirements for this study. The SPSC had better internal consistency than the SP, but the SP also maintained fair internal consistency. Self-report measures such as the SP and SPSC are flawed in terms of objectivity of the respondent and interpretation of statements, as was demonstrated by the SP in terms of alpha values. The SPSC had more correlations with the SIPT than the SP. The SIPT met the requirements in terms of the data that was obtained, but also demonstrated that when used in conjunction with other measurement instruments in correlational studies, it does not live up to expectations. This may be due to the complex nature of underlying constructs and that more detailed and intricate analysis is required to expose similar characteristics.

5.6.1.2 Concurrent Questions

The research results also prompted some questions that are based on the deductions made. These questions can be addressed in future research studies.

- The role of SUR in dyspraxia was not satisfactorily explained, specifically because clinical analysis of a SMD sample revealed that dyspraxia had a higher representation in SUR. Does SUR affect discrimination and to what extent?
- This study looked at SUR and SOR, but did not consider fluctuating sensory responsivity. Is the difference in the representation of quadrants of the SP and SPSC (Figures 4.4 and 4.5) due to fluctuating responsiveness, where a child with seeking behaviour at home crosses over to avoiding behaviour due to changes in environment and the type and intensity of sensory input?
- What is the extent of the impact of SUR or SOR of the auditory system on central auditory processing and, subsequently, language? What is the concurrent effect on praxis and how does it manifest in terms of the types of dyspraxia and ideation?
- The behavioural sections of the SP and SPSC had no correlations with any of the SIPT groups. This result leads to the question that if behaviour is an expression of dysfunction (dyspraxia) then is the behaviour observed in children with Developmental Dyspraxia a functional expression of dyspraxia? Also, is SUR or SOR that occur with Developmental Dyspraxia not the primary source of the behaviour we think is typical of children with dyspraxia?

5.6.2 Accomplishment of Research Aim

The research aim was accomplished, as an answer to the research question was obtained. The answer to the question did not support the alternative hypotheses

and did not reject the null hypotheses. This study aimed at establishing if a relationship existed between Developmental Dyspraxia and Sensory Responsivity. Although there was not overwhelming support for the alternative hypotheses, some interesting weak relations were observed that resulted in valid deductions and led to the formulation of legitimate questions in lieu of the conclusions and deductions.

It is the opinion of the researcher that the accomplishment of a research aim does not only depend on obtaining support for a hypothesis, but also relies on the subsequent valuable observations and deductions made that contribute to a body of knowledge and culminate in recommendations that will give direction to future research studies. From this perspective the research aim was accomplished.

The research objectives for this study were to determine if Sensory Under- or Over-Responsivity and Developmental Dyspraxia are related. Statistical analyses of data, again, did not generate enough evidence to support alternative hypotheses, but produced interesting correlations that deserved further interpretation and analysis. Even though positive relations that support the alternative hypotheses were lacking and led to the null hypotheses for objectives not being rejected, the conclusions and questions that ensued from observed correlations are valid and have the potential to make a contribution in the field of this research study.

5.7 RECOMMENDATIONS

Based on the fact this study did not produce satisfactory evidence to support a relation between Developmental Dyspraxia and Sensory Responsivity and, as such, does not contribute to changes in treatment of Developmental Dyspraxia, the focus will be on recommendations for future research. Some recommendations regarding practice and evaluation in the clinical field will also

be made and originate from retrospective evaluation of the study and the ensuing outcomes.

5.7.1 Recommendations for Future Research

Through this study some interesting deductions were made from which legitimate questions arose. These questions relate to some extent to the recommendations for future research and thus the important questions are discussed.

- The SPSC proved to have better internal consistency reliability and had more correlations with the SIPT than the SP. It is therefore recommended that the SPSC be used in more research studies to validate its use and to provide a basis from which the SPSC's contribution and value in providing solid research data to studies of sensory responsiveness can be established. A study that investigates differences in behaviours between the classroom and the home will provide interesting information, specifically if such a study examines how behaviours change between quadrants from one environment to the next.

- From the correlations and subsequent conclusions it is recommended that the relation of SOR and generalised SI dysfunction be further explored in terms of the severity of generalised SI dysfunction in a population of children with SOR. The prevalence of SOR in children with generalised SI dysfunction should also be investigated. Parent and teacher reporting would be vital to determine the effects the environment has on behaviour as well as on the tendency to avoid sensory experiences.

- The role of SUR in ideation in visio- and somatodyspraxia is another suggestion for future research. The inverse correlations of auditory SUR and SOR with this type of dyspraxia, good praxis on verbal command ability and the high representation of visio- and somatodyspraxia in SUR

(clinincal analysis) has led the researcher to speculate that SUR may play a major role in ideation. This should be clarified through the investigation of the function of ideation in visio- and somatodyspraxia, the components that make up ideation and if SUR possibly could impact on ideation.

- It would also be valuable to investigate if SUR of the auditory system impacts on central auditory processing and language, specifically considering the inverse correlation of SOR with dyspraxia on verbal command and based on the clinical observation of SUR in children with this type of dyspraxia.

- Another valid recommendation for future research of this kind relates to analysis of data generated from the SIPT, SP and SPSC. As discussed in Section 5.4.3, conducting factor analysis on data obtained from the SIPT, SP and SPSC would shed light on similarities or differences of underlying constructs and provide more intricate analysis results of complex constructs, such as Sensory Responsivity and Developmental Dyspraxia. To accomplish this, a bigger sample is required.

- The role of behaviour in sensory responsivity and dyspraxia is not clarified. The researcher assumed that in this study behaviour as an expression of function will have a correlation with Developmental Dyspraxia and SUR or SOR. From the results no correlation was observed and led to the question “Is the behaviour assumed to be typical of children with dyspraxia not due to SOR or SUR, which either results in avoidance behaviour or alternatively affects ideation?” Investigation of behaviour as a functional, social expression of Developmental Dyspraxia or conversely as an expression of SUR or SOR is indicated to explain the lack of a correlation between Developmental Dyspraxia and behaviour on the SP and SPSC.

5.7.2 Recommendations for Clinical Practice

It is the opinion of the researcher that a measurement instrument like the SPSC should be used along with the SP in all Sensory Integration evaluations to discern between behaviour tendencies at home and at school. The significant response differences in frequency of observed behaviours between caregivers and teachers, seen in Figure 5.1, emphasise the need to establish to what extent the environment impacts on children's sensory responsiveness patterns.

Furthermore, is it of importance that the manner in which Sensory Modulation is assessed be reviewed in terms of the measurement instruments, as well as the frequency with which it is done and the approach that is used. Self report measures are flawed from certain viewpoints[82], but the SP and SPSC are psychometrically sound. One option is to keep on using these measures or to look at alternative ways to assess Sensory Modulation.

Until there is a measure of Sensory Modulation that incorporates both self reporting and functional observation, the researcher suggests an approach that emphasises the importance of the SPSC and SP as part of a comprehensive assessment that relies just as much on the information provided through self reporting as on standardised tests. To enhance the use of self report instruments, the use of a top-down approach is recommended to add value to the SP and SPSC. This will allow careful scrutiny of functional performance and relate it to sensory modulation behaviour and components of praxis if the SIPT is used.

In conclusion, this study highlighted some weak inverse and positive relations between Developmental Dyspraxia and Sensory Responsiveness, specifically of types of dyspraxia with SUR and SOR. These relations were supported by clinical analysis. Clinical analysis also highlighted and supported conspicuous trends in the internal consistency of some data and assisted in delineating the

reasons for that. Furthermore, the information obtained from this study is intended to give direction to and provide ideas for future research. It is the sincere hope of the researcher that this study will alter and add to perceptions of sensory responsiveness and its association with Developmental Dyspraxia. It has certainly exposed the layers that make up constructs like dyspraxia and sensory responsiveness and how these layers interact with each other. Information from this study may assist occupational therapists in their interpretation of sensory responsiveness tendencies in the presence of Developmental Dyspraxia. It will also hopefully raise awareness that certain types of dyspraxia have more pronounced links with sensory under- and over-responsiveness and will assist therapists in promptly and accurately identifying SUR or SOR.

REFERENCES

1. Giuffrida C. Praxis, motor planning and motor learning. In: Smith Roley S, Blanche EI, Schaaf RC, editors. Understanding the nature of sensory integration with diverse populations. San Antonio: Therapy Skill Builders; 2001. p. 133-161.
2. Bundy AC, Murray EA. Sensory integration: A Jean Ayres' theory revisited. In: Bundy AC, Lane SJ, Murray EA, editors. Sensory integration theory and practice. 2nd ed. Philadelphia: FA Davis Company; 2002. p. 3-33.
3. Parham LD, Mailloux Z. Sensory integration. In: Case-Smith J, editor. Occupational therapy for children. 5th ed. St Louis: Elsevier Mosby; 2005. p. 356-409.
4. Smith Roley S. Sensory integration theory revisited. In: Schaaf RC, Smith Roley S, editors. Sensory integration: Applying clinical reasoning to practice with diverse populations. Austin: PRO-ED; 2006. p. 1-13.
5. Smith Roley S, Blanche EI, Schaaf RC, editors. Sensory integration with diverse populations. San Antonio: Therapy Skill Builders; 2001.
6. Lane SJ. Sensory modulation. In: Bundy AC, Lane SJ, Murray EA, editors. Sensory integration theory and practice. 2nd ed. Philadelphia: FA Davis Company; 2002. p. 101-122.
7. Lane SJ, Miller LJ, Hanft BE. Toward a consensus in terminology in sensory integration theory and practice: Part 2: Sensory integration patterns of function and dysfunction. Sensory Integration Special Interest Section Quarterly. 2000 Jun;23(2):1-3.
8. Ayres AJ. Sensory integration and the child. 25th anniversary ed. Los Angeles: Western Psychological Services; 2005.
9. Miller LJ, Anzalone ME, Lane SJ, Cermack SA, Osten ET. Concept evolution in sensory integration: A proposed nosology for diagnosis. American Journal of Occupational Therapy. 2007 Mar/Apr;61(2):135-140.

10. Miller LJ, Lane SJ. Toward a consensus in terminology in sensory integration theory and practice: Part 1: Taxonomy of neurophysiological processes. Sensory Integration Special Interest Section Quarterly. 2000 Mar;23(1):1-4.
11. Cermack SA. Somatodyspraxia. In: Fisher AG, Bundy AC, Murray EA, editors. Sensory integration theory and practice. Philadelphia: FA Davis Company; 1991. p. 137-170.
12. Case-Smith J. Occupational therapy for children. 5th ed. St. Louis: Elsevier Mosby; 2005.
13. Fisher AG, Murray EA, Bundy AC. Appendix 8-A. Validity of SIPT scores. In: Fisher AG, Murray EA, Bundy AC, editors. Sensory integration theory and practice. Philadelphia: FA Davis Company; 1991. p. 230-233.
14. Murray-Slutsky C. Somatodyspraxia and intervention strategies. In: Murray-Slutsky C, Paris B, editors. Exploring the spectrum of autism and pervasive developmental disorders. San Antonio: Therapy Skill Builders; 2000. p. 237-277.
15. Blanche EI. The evolution of the concept of praxis in sensory integration. In: Smith Roley S, Blance EI, Schaaf RC, editors. Understanding the nature of sensory integration with diverse populations. San Antonio: Therapy Skill Builders; 2001. p. 125-131.
16. Dahl Reeves G, Cermack SA. Disorders of praxis. In: Fisher AG, Murray EA, Bundy AC, editors. Sensory integration theory and practice. 2nd ed. Philadelphia: FA Davis Company; 2002. p. 71-100.
17. Fisher AG, Murray EA, Bundy AC. Glossary. In: Fisher AG, Murray EA, Bundy AC, editors. Sensory integration theory and practice. 2nd ed. Philadelphia: FA Davis Company; 2002. p. 477-480.
18. Ayres AJ. Developmental dyspraxia and adult onset apraxia. Torrance (CA): Sensory Integration International; 1985.
19. Murray-Slutsky C, Paris B. Sensory modulation. In: Murray-Slutsky C, Paris B, editors. Exploring the spectrum of autism and pervasive developmental disorders. San Antonio: Therapy Skill Builders; 2000. p. 107-124.

20. Miller LJ, Reisman JE, McIntosch DN, Simon J. An ecological model of sensory modulation: Performance of children with fragile X syndrome, autistic disorder, attention-deficit/hyperactivity disorder, and sensory modulation. In: Smith Roley S, Blanche EI, Schaaf RC, editors. Understanding the nature of sensory integration with diverse populations. San Antonio: Therapy Skill Builders; 2001. p. 57-84.
21. Ayres AJ. Development and standardization of the SIPT. In: Ayres AJ, editor. Sensory Integration and Praxis Tests manual. updated ed. Los Angeles: Western Psychological Services; 2004. p. 153-170.
22. Brown T, Leo M, Austin DW. Discriminant validity of the sensory profile in Australian children with autism spectrum disorder. Physical and Occupational Therapy in Paediatrics. 2008 Jul 9;28(3):253-266.
23. Neuman A. Patterns of response to sensory stimuli encountered in daily activities: A comparison between 3 to 10-year-old Israeli and American children without disabilities. Occupational Therapy International. 2006 Jan 25;13(2):79-99.
24. Dunn W, Westman K. The sensory profile: The performance of a national sample of children without disabilities. American Journal of Occupational Therapy. 1997 Jan 6;51(1):25-34.
25. Spitzer S, Smith Roley S. Sensory integration revisited: A philosophy of practice. In: Smith Roley S, Blanche EI, Schaaf RC, editors. Understanding the nature of sensory integration with diverse populations. San Antonio: Therapy Skill Builders; 2001. p. 3-27.
26. Hanft BE, Miller LJ, Lane SJ. Toward a consensus in terminology in sensory integration theory and practice: Part 3: Observable behaviors: Sensory integration dysfunction. Sensory Integration Special Interest Section Quarterly. 2000 Sept;23(3):1-4.
27. May-Benson TA, Cermak SA. Development of an assessment for ideational praxis. American Journal of Occupational Therapy. 2007 Mar/Apr;61(2):148-153.

28. Mulligan S. Patterns of sensory integration dysfunction: A confirmatory factor analysis. American Journal of Occupational Therapy. 1998 Apr 14;52(10):819-828.
29. Zwicker JG, Harris SR. A reflection on motor learning theory in pediatric occupational therapy practice. Canadian Journal of Occupational Therapy. 2009 Feb;76(1):29-37.
30. Higgins S. Motor skill acquisition. Phys Ther. 1991 Feb;71(2):123-139.
31. Mathiowetz V, Haugen JB. Motor behavior research: Implications for therapeutic approaches to central nervous system dysfunction. American Journal of Occupational Therapy. 1994 Jan 24;48(8):733-745.
32. Winstein CJ. Knowledge of results and motor learning - implications for physical therapy. Physical Therapy. 1991 Feb;71(2):140-149.
33. Lane SJ. Structure and function of the sensory systems. In: Bundy AC, Lane SJ, Murray EA, editors. Sensory integration theory and practice. 2nd ed. Philadelphia: F.A. Davis Company; 2002. p. 35-70.
34. Mulder T. A process-oriented model of human motor behavior: Toward a theory-based rehabilitation approach. Physical Therapy. 1991 Feb;71(2):157-164.
35. Lee DL, Swanson LR, Hall AL. What is repeated in a repetition? Effects of practice conditions on motor skill acquisition. Physical Therapy. 1991 Feb;71(2):150-156.
36. Gliner JA. Purposeful activity in motor learning theory: An event approach to motor skill acquisition. American Journal of Occupational Therapy. 1985 Jan;39(1):28-34.
37. Baranek GT, Chin YH, Greiss Hess LM, Yankee JG, Hatton DD, Hooper SR. Sensory processing correlates of occupational performance in children with fragile X syndrome: Preliminary findings. American Journal of Occupational Therapy. 2002 Oct;56(5):538-546.
38. May-Benson TA. A theoretical model of ideation in praxis. In: Smith Roley S, Blanche EI, Schaaf RC, editors. Understanding the nature of sensory

integration with diverse populations. San Antonio: Therapy Skill Builders; 2001. p. 163-181.

39. Schoen SA, Miller LJ, Green KE. Pilot study of the sensory over-responsivity scales: Assessment and inventory. American Journal of Occupational Therapy. 2008 Jul/Aug;62(4):393-406.
40. Goodgold-Edwards SA, Cermak SA. Integrating motor control and motor learning concepts with neuropsychological perspectives on apraxia and developmental dyspraxia. American Journal of Occupational Therapy. 1990 May;44(5):431-439.
41. Willoughby C, Polatajko HJ. Motor problems in children with developmental coordination disorder: Review of the literature. American Journal of Occupational Therapy. 1995;49:787-793.
42. Case-Smith J. Clinical interpretation of "factor analysis on the sensory profile from a national sample of children without disabilities". American Journal of Occupational Therapy. 1997 Jul;51(7):496-499.
43. Ben-Sasson A, Cermack SA, Orsmond GI, Tager-Flusberg H, Carter AS, Kadlec MB, et al. Extreme sensory modulation behaviors in toddlers with autism spectrum disorders. American Journal of Occupational Therapy. 2007 Oct;61(5):584-592.
44. Reynolds S, Lane SJ. Diagnostic validity of sensory over-responsivity: A review of the literature and case reports. Journal of Autism Developmental Disorders. 2007 Oct 5;38:21 July 2009.
45. Wilbarger J, Stackhouse TM. Sensory modulation: A review of the literature [monograph on the Internet]. 2006 [cited 2009 Jul 31]. Available from: www.ot-innovations.com/content/view/29/58.
46. Dunn W. The 2001 Eleanor Clarke Slagle lecture. The sensations of everyday life: Emperical, theoretical, and pragmatic considerations. American Journal of Occupational Therapy. 2001 Jul;55(6):608-620.
47. Ayres AJ. Description of the SIPT. In: Ayres AJ, editor. Sensory and Praxis Tests Manual. Updated ed. Los Angeles: Western Psychological Services; 2004. p. 1-8.

48. Ayres AJ. Validity and reliability of the SIPT. In: Ayres AJ, editor. Sensory Integration and Praxis Tests Manual. Updated ed. Los Angeles: Western Psychological Services; 2004. p. 171-217.
49. Lai JS, Fisher AG, Magalhaes LC, Bundy AC. Construct validity of the Sensory Integration and Praxis Tests. Occupational Therapy Journal of Research. 1996 Spring;16(2):75-91.
50. Mulligan S. Cluster analysis of scores of children on the sensory integration and praxis tests. Occupational Therapy Journal of Research. 2000;20:256-270.
51. Asher AV, Parham LD, Knox S. Inter-rater reliability of sensory integration and praxis tests (SIPT) score interpretation. American Journal of Occupational Therapy. 2008 May/Jun;62(3):308-319.
52. Kimball JG. Using the sensory integration and praxis tests to measure change: A pilot study. American Journal of Occupational Therapy. 1990 Mar 1;44(7):603-608.
53. Mulligan S. An analysis of score patterns of children with attention disorders on the sensory integration and praxis tests. American Journal of Occupational Therapy. 1996 Sept;50(8):647-654.
54. Chu S. Evaluating the sensory integrative functions of mainstream school children with specific developmental disorders. British Journal of Occupational Therapy. 1996 Oct;59(10):465-474.
55. Lin SH, Cermak S, Costner WJ, Miller L. The relation between length of institutionalization and sensory integration in children adopted from Eastern Europe. American Journal of Occupational Therapy. 2005;59(2):139-147.
56. Cermak SA, Morris ML, Koomar J. Praxis on verbal command and imitation. American Journal of Occupational Therapy. 1990 Jul;44(7):641-645.
57. Cermak SA, Murray EA. The validity of the constructional subtests of the Sensory Integration and Praxis Tests. American Journal of Occupational Therapy. 1991 Jun;45(6):539-543.

58. Murray EA, Cermak SA, O'Brien V. The relationship between form and space perception, constructional abilities, and clumsiness in children. American Journal of Occupational Therapy. 1990 Jul;44(7):623-628.
59. McAtee S, Mack W. Relations between design copying and other tests of sensory integrative dysfunction: a pilot study. American Journal of Occupational Therapy. 1990 Jul;44(7):596-601.
60. Dunn W. Overview. In: Dunn W, editor. Sensory Profile user's manual. San Antonio: The Psychological Corporation; 1999. p. 1-8.
61. Dunn W, Brown C. Factor analysis on the sensory profile from a national sample of children without disabilities. American Journal of Occupational Therapy. 1997 Jul/Aug 1997;51(7):490-495.
62. Dunn W. Technical characteristics. In: Dunn W, editor. Sensory Profile user's manual. San Antonio: The Psychological Corporation; 1999. p. 47-55.
63. Ermer J, Dunn W. The sensory profile: A discriminant analysis of children with and without disabilities. American Journal of Occupational Therapy. 1998 April;52(4):283-290.
64. Dunn W, Bennett D. Patterns of sensory processing in children with attention deficit hyperactivity disorder. Occupational Therapy Journal of Research. 2002 Winter;22(1):4-15.
65. Yochman A, Parush S, Ornoy A. Responses of preschool children with and without ADHD to sensory events in daily life. American Journal of Occupational Therapy. 2004;58(3):294-302.
66. Watling RL, Deitz J, White O. Comparison of sensory profile scores of young children with and without autism spectrum disorders. American Journal of Occupational Therapy. 2001 Jul/Aug;55(4):416-423.
67. Dunn W, Myles BS, Orr S. Sensory processing issues associated with Asperger syndrome: a preliminary investigation. American Journal of Occupational Therapy. 2002;56(1):97-102.
68. Gere DR, Capps SC, Mitchell DW, Grubbs E. Sensory sensitivities of gifted children. American Journal of Occupational Therapy. 2009 May/Jun;63(3): 288-295.

69. Bharadwaj SV, Daniel LL, Matzke PL. Sensory-processing disorder in children with cochlear implants. American Journal of Occupational Therapy. 2009;63(2):208-213.
70. Newmeyer AJ, Aylward C, Akers R, Ishikawa K, Grether S, deGrauw T, et al. Results of the sensory profile in children with suspected childhood apraxia of speech. Physical and Occupational Therapy in Paediatrics. 2009;29(2):203-218.
71. White PB, Mulligan S, Merrill K, Wright J. An examination of the relationships between motor and process skills and scores on the Sensory Profile. American Journal of Occupational Therapy. 2007 Mar/Apr;61(2):154-160.
72. Dunn W. Overview. In: Dunn W, editor. Sensory Profile School Companion user's manual. San Antonio: Harcourt Assessment; 2006. p. 1-4.
73. Dunn W. History and development. In: Dunn W, editor. Sensory Profile School Companion user's manual. San Antonio: Harcourt Assessment; 2006. p. 11-27.
74. Dunn W. Technical Properties. In: Dunn W, editor. Sensory Profile School Companion user's manual. San Antonio: Harcourt Assessment; 2006. p. 83-99.
75. Dunn W. Administration instructions and scoring. In: Dunn W, editor. Sensory Profile user's manual. San Antonio: The Psychological Corporation; 1999. p. 23-29.
76. Polit DF, Tatano Beck C, Hungler BP. Understanding quantitative research design. In: Polit DF, Tatano Beck C, Hungler BP, editors. Essentials of nursing research. 5th ed. Philadelphia: Lippincott Williams & Wilkens; 2001. p. 165-202.
77. Ayres AJ. Computerized scoring and interpretation. In: Ayres AJ, editor. Sensory Integration and Praxis Tests manual. updated ed. Los Angeles: Western Psychological Services; 2004. p. 109-129.
78. Dunn W. Administration and scoring. In: Dunn W, editor. Sensory Profile School Companion user's manual. San Antonio: Harcourt Assessment; 2006. p. 29-35.

79. Gliem JA, Gliem RR, editors. Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for likert-type scales. Proceedings of the Midwest Research-to-Practice Conference in Adult, Continuing, and Community Education; 2003 Oct 8-10; Columbus OH: Ohio State University; 2003.
80. Yu CH, editor. An introduction to computing and interpreting Cronbach coefficient alpha in SAS. Proceedings of the 26th Annual SAS Users Group International Conference; 2001 Apr 22-25; Cary, NC, USA: SAS Institute Inc; 2001.
81. Ayres AJ. Interpretation of the SIPT scores. In: Ayres AJ, editor. Sensory Integration and Praxis Tests manual. Updated ed. Los Angeles: Western Psychological Services; 2004. p. 131-152.
82. Dickie VA, Baranek GT, Schultz B, Watson LR, McComish CS. Parent reports of sensory experiences of preschool children with and without autism: A qualitative study. American Journal of Occupational Therapy. 2009 Mar/Apr;63(2):172-181.
83. Parham LD. The relationship of sensory integrative development to achievement in elementary students: four-year longitudinal patterns Occupational Therapy Journal of Research. 1998;18(3):105-127.
84. Bundy AC, Shia S, Qi L, Miller LJ. How does sensory processing dysfunction affect play? American Journal of Occupational Therapy. 2007 Apr;61:201-208.
85. Parush S, Sohmer H, Steinberg A, Kaitz M. Somatosensory function in boys with ADHD and tactile defensiveness. Physiology and Behavior. 2007 Nov;90:553-558.
86. Walker KF, Burris B. Correlation of sensory integration and praxis test scores with metropolitan achievement test scores in normal children. Occupational Therapy Journal of Research. 1991 Oct;11(5):307-310.