SENSORY MODULATION PATTERNS IN CHILDREN WITH CEREBRAL PALSY: A COMPARATIVE-DESCRIPTIVE STUDY

by

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DECLARATION

I, Shánna Louwrens, hereby declare that the work in this dissertation is my own. Acknowledgement was given to work done by others. The work in this dissertation has not been previously submitted at another university for degree purposes.

Signature

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ABSTRACT

Cerebral palsy (CP) causes complex motor and sensory impairments. The motor impairments are well documented in the literature. More recently, researchers have focused on the sensory impairments associated with CP. Sensory modulation disorders (SMD) are identified when children are unable to adequately regulate and grade their responses to sensory inputs to such an extent that it significantly impairs their ability to participate in various areas of occupation. Although there is evidence that children with CP present with SMD, there is no evidence that different types of CP present with different sensory modulation patterns (SMP).

The Sensory Profile 2, a well-recognised, standardised questionnaire, was completed by 154 parents/guardians of learners diagnosed with CP, aged between 5.0 to 14.11 years old, in order to (i) determine the predominant SMP in children with CP and (ii) determine whether significant differences existed between the different subtypes of CP. The registration (72.73%) and avoiding (53.90%) patterns were the most prevalent in the CP group. The CP group had a high prevalence of body position (77.92%), movement (56.49%), visual processing (53.25%), and social-emotional (55.84%) difficulties. There was a significant difference between the mean score in the body position processing section (p=0.000) between the ataxic (n=21), dyskinetic (n=21), spastic diplegic (n=61), and spastic hemiplegic (n=49) subtypes. Furthermore, some proportional differences existed between some subtypes. The ataxic and dyskinetic subtypes had a higher percentage of participants scoring out of the norm, reflecting more SMD than the other subtypes. Touch processing difficulties were common in the spastic hemiplegic subtype, which is consistent with clinical observations. The spastic diplegic subtype presented with fewer SMD than the other subtypes.

The study confirmed the presence of SMD in children with CP and provided some statistical evidence that different types of CP present with different SMP. These findings will assist occupational therapists to assess and treat these impairments more effectively.

KEYWORDS: Sensory modulation; sensory modulation disorder; sensory modulation patterns; cerebral palsy; Sensory Profile 2; assessment

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LIST OF ABBREVIATIONS

A	Ataxia/ataxic
ADHD	Attention Deficit and Hyperactivity Disorder
ANOVA	Analysis of Variance
ANS	Autonomic Nervous System
ASD	Autism Spectrum Disorders
ASI	Ayres Sensory Integration
Att	Attentional behavioural response
Au	Auditory processing
Bo	Body position processing
CAPS	Curriculum Assessment Policy Statements
CI	Confidence Interval
CNS	Central Nervous System
Con	Conduct behavioural response
CP	Cerebral Palsy
DCML	Dorsal Column-Medial Lemniscal
DNA	Does Not Apply
DY	Dyskinesia/dyskinetic
ELBW	Extremely Low Birth Weight
GDE	Gauteng Department of Education
GMFCS	Gross Motor Function and Classification System
HIV	Human Immunodeficiency Virus
HLOE	Highest Level of Education
ICF	International Classification of Functioning, Disability and Health
ID	Intellectual Disabilities
IQ	Intellectual Quotient
JL	Just Like
LBW	Low Birth Weight
LD	Learning Disabilities
LNBW	Less Than Normal Birth Weight
LSEN	Learners with Special Educational Needs
LT	Less Than
MACS	Manual Abilities Classification Scale

MID	Mild Intellectual Disabilities
ML	Much Less
MM	Much More
Mo	Movement processing
MOID	Moderate Intellectual Disabilities
MRI	Magnetic Resonance Imaging
MT	More Than
NBW	Normal Birth Weight
NDT	Neurodevelopmental Therapy
Or	Oral sensory processing
PID	Profound Intellectual Disabilities
RAS	Reticular Activating System
SA	South Africa/African
SCPE	Surveillance of Cerebral Palsy in Europe
Sd	Standard Deviation
SD	Spastic Diplegia/diplegic
SDD	Sensory Discrimination Disorders
SES	Socio Economic Status
SGB	School Governing Body
SH	Spastic Hemiplegia/hemiplegic
SI	Sensory Integration
SID	Severe Intellectual Disabilities
SIPT	Sensory Integration and Praxis Tests
SLD	Specific Learning Disabilities
SMD	Sensory Modulation Disorders
SMP	Sensory Modulation Patterns
Soc	Social-emotional behavioural response
SP2	Sensory Profile 2
SPD	Sensory Processing Disorder
SQ	Spastic Quadriplegia/quadriplegic
SS	Sensory Seeking
SSP	Short Sensory Profile
To	Touch processing
TD	Typically Developing

Vi	Visual processing
VLBW	Very Low Birth Weight

CHAPTER 1
ORIENTATION TO THE STUDY

1.1 INTRODUCTION

Sensory modulation refers to neurophysiological processes occurring in the central nervous system (CNS), which regulate and grade the degree, nature and intensity of incoming sensory input.[1-2] From a behavioural perspective, it refers to the ability to respond appropriately to sensory information in accordance with the demands of the environment.[2-4] Impairments in these processes result in over- or under-responsivity; and are referred to as sensory modulation disorders (SMD).[4] Sensory modulation emanates from sensory integration (SI) theory, which was developed by Dr Jean Ayres in the 1960's, whilst working with children with learning disabilities (LD).[4] Sensory integration disorders refer to the inability to adequately process, modulate, discriminate, integrate or adapt to sensory information; resulting in behaviours which negatively impact on the child's functioning.[2-3] Ayres' work focused on children with LD, but she recognised that sensory processing impairments might be contributing to the functional impairments associated with cerebral palsy (CP).[5] She, however, never completed her research in children with CP.

Although Ayres' initial work remains foundational within current SI theory; the theory as well as the application of the theory is continuously developing based on ongoing research in the field.[6] Different researchers or research groups have adopted slightly different terminology to describe SMD, as well as the theory of sensory modulation. For this study, the researcher has chosen to use the terminology proposed by Miller et al. (2007).[4] This taxonomy replaces the term sensory integration disorders with the term sensory processing disorders (SPD). SPD are an umbrella term for different sensory-based processing challenges, including SMD.[4]

The literature highlights the impact that SMD have on school performance, social participation, play, leisure, as well as participation in daily activities and routines.[7-13] Due to the significant impact on all functional areas, several attempts have been made to have SPD included in the Diagnostic and Statistical Manual of Mental Disorders-

Fifth-edition (DSM-V). Despite the fact that it is still not yet recognised as a clinical diagnosis in the DSM-V; SPD are gaining recognition in the medical field, with the inclusion of processing disorders as a diagnostic criterion for autism spectrum disorders (ASD).[4,14] Moreover, sensory processing regulation difficulties are recognised in the Diagnostic Classification of Mental Health and Developmental Disorders of Infancy and Early Childhood.[15]

Occupational therapists frequently assess and treat SMD in children.[16] Approximately five percent of typically developing (TD) kindergarten children (zero-to-three years) in the United States of America have SMD.[17] The prevalence of SMD in children with disabilities is significantly higher than the TD population. Studies have found that a 40-88% children with developmental disabilities present with SMD.[17-20] Various disability groups present with SMD, including ASD,[19,21-27] attention deficit and hyperactivity disorders (ADHD),[23,27-30] intellectual disabilities (ID),[31] fragile X syndrome,[18,32] and specific language impairments.[33] The majority of studies have focused on ASD and ADHD. No studies have examined the prevalence of SMD in South Africa (SA).

Further investigation is still required to confirm whether SMD occur as part of the primary condition or as a separate condition.[34] More recently, researchers have tried to identify whether specific patterns of sensory modulation occur. There is growing evidence to suggest that distinct sensory processing patterns occur in different conditions and that these may differ between disability groups.[23,26-27,30,34-35] These studies have predominantly used the Sensory Profile (SP) and the shorter version, the Short Sensory Profile (SSP).[36] The SP and SSP are considered to be useful and valid measures to assess sensory modulation in a variety of disability groups.[23,28,33,37] It is essential to identify the specific types of SPD prevalent in different conditions to implement successful intervention, as well as for diagnostic purposes.[34,38]

Cerebral palsy, the most commonly occurring disability in childhood,[39] can be described as a sensorimotor disorder.[40] Karl and Bertha Bobath, the pioneers of Neurodevelopmental Therapy (NDT), already acknowledged the influence of sensory development on abnormal movement in the early 1970's.[41] They believed that children did not learn movement per se, but instead they learned the "sensation of movement".[41] There is a wealth of literature documenting the motor impairments which interfere with motor function and daily activities, including spasticity, muscle contractures, decreased range of motion, incoordination, loss of selective motor control, and muscle weakness.[41-43] Cooper (1995) stated that sensory input is an essential component of motor function and motor control.[44] However, despite this, classification, research and intervention in the CP population continues to concentrate on the motor impairments.

Current theories of motor control,[45] as well as advances in neuroimaging studies,[46-50] indicate that movement and sensation are indeed related.[51] Subsequently, the notion that sensory processing impairments contribute to the observed motor difficulties in children with CP has gained ground.[51-52] In particular, somatosensory (tactile and proprioceptive) processing is considered to play a crucial role in the development of motor function.[50,53] Subsequently, more research is examining these impairments in children with CP.[44,50-51,53-64] The majority of the research that has been conducted has examined the sensory discrimination deficits, as well as the somatosensory processing deficits in children with CP, especially in children with hemiplegia.[51] The exact cause of sensory deficits in CP remains unclear.[59] Researchers are examining whether damage to the somatosensory cortex causes the deficits, or whether impairments in the ascending tracts contribute to the sensory deficits.[50,52,65-66]

Children with CP frequently present with SPD, including discrimination, modulation and praxis disorders.[5,67] A few studies have examined SMD in children with CP, using the SP and SSP.[37,68-71] The specific sensory modulation patterns (SMP) or SMD prevalent in children with CP have not been clearly described in the research done thus far. A possible explanation for the limited research in this population, in comparison to other diagnostic groups, is that there is contention among SI theorists about whether the theory of sensory modulation can be applied to children with CP. Within SI theory, SMD are thought to be caused by central processing dysfunctions. The controversy exists because CP involves damage to the cortical regions of the CNS.[2,72] Despite this, sensory-based strategies are frequently used by occupational therapists to treat these difficulties.[56,73]

1.2 PROBLEM STATEMENT

Although children with CP present with SMD, these disorders are challenging to diagnose in children with CP because many of the symptoms or behavioural characteristics may be related to the damage to the CNS.[2,5,74] According to Blanche and Nakasuji (2001),[5] these impairments could affect the child's functioning more than the motor impairments associated with CP; however, they are often masked by the motor impairments, resulting in them being undetected.[5]

Interest in SMD in CP has piqued in the last decade. Several studies have confirmed the presence of SMD in the CP population using the SP and SSP; however, none of the studies were done in SA.[37,68-71] The unique social, cultural, and economic barriers imposed on children with CP in urban settings in SA may contribute to the sensory impairments that these children experience, further necessitating research in SA. These challenges include insufficient access to medical and therapeutic intervention, as well as the lack of availability of assistive devices.[75-76] Children with CP predominantly attend schools for learners with special educational needs (LSEN). Although many of the children may have access to assistive devices, such as wheelchairs or walking aids at school, they may not be able to access these devices at home; thereby, limiting their ability to be independent in all contexts. Similarly, they may be able to access therapeutic interventions at school, but the therapy that they receive may be limited due to shortages in staff or high case-loads. Other challenges include that children with CP are often marginalised and stigmatised in their communities due to cultural beliefs and lack of education.[76-78] Due to these social and cultural factors, children with CP may be excluded in social activities, which could negatively influence their play occupations.

Experts in the field have proposed that children with different types of CP present with different SMP.[5,67] These assumptions are based on clinical observations and experience, and at present no empirical evidence is available to support the hypothesis. Previous studies using the SP and SSP did not compare SMP in the different subtypes because they had small sample sizes, or they excluded some of the subtypes of CP.[37,68-71,79]

There is a significant gap in the literature with regards to SMD in children with CP, as well as how this may impact on the child's functioning. Subsequently, sensory modulation may not be routinely assessed or treated in children with CP. Intervention for children with CP is less likely to succeed if occupational therapists fail to consider the possibility of sensory impairments and only address the motor impairments. Despite the lack of research available, practitioners treat SMD in children with CP using sensory integration and sensory-based treatment strategies, without fully understanding the types of SMD that children with different types CP might have. Effective therapeutic intervention relies on the accurate evaluation of abilities and impairments. Therefore, it is imperative that researchers determine whether specific types of SMD occur in children with different types of CP. It is also important to ascertain whether the different subtypes present with unique patterns of sensory modulation so that clinicians can implement precise treatment goals and interventions.

1.3 RESEARCH QUESTION

Do children with different types of cerebral palsy, that is, ataxic, dyskinetic, and spastic (hemiplegic, diplegic, and quadriplegic) present with different patterns of sensory modulation?

1.4 RESEARCH AIM

The study aimed to determine whether different sensory modulation patterns occur in different types of cerebral palsy.

1.5 RESEARCH OBJECTIVES

The objectives of the study were related to the data obtained from the Sensory Profile 2 (SP2). The SP2 is comprised of the following sections:

- The **sensory modulation quadrants:** seeking, avoiding, sensitivity, and registration;
- The **sensory systems:** auditory, visual, touch, movement, body position, and oral sensory processing; and

- The **behavioural responses:** conduct, social-emotional, and attentional.

The objectives of the study were to:

1. Describe the predominant sensory modulation pattern(s) in the quadrants in children with cerebral palsy.
2. Describe the quality of sensory modulation in the different sensory systems in children with cerebral palsy.
3. Describe the predominant behavioural responses associated with sensory modulation in children with cerebral palsy.
4. Compare the predominant sensory modulation pattern(s) in the quadrants between the ataxic, dyskinetic, and spastic (diplegic, hemiplegic, and quadriplegic) subtypes.
5. Compare the quality of sensory modulation in the different sensory systems between the ataxic, dyskinetic, and spastic (diplegic, hemiplegic, and quadriplegic) subtypes.
6. Compare the predominant behavioural responses associated with sensory modulation between the ataxic, dyskinetic, and spastic (diplegic, hemiplegic, and quadriplegic) subtypes.

1.6 RESEARCH HYPOTHESES

The researcher chose the following hypotheses for the comparative objectives described above:

Objective: Compare the predominant sensory modulation pattern(s) in the quadrants between the different subtypes of CP.
Null Hypothesis: There will be no significant difference in the sensory modulation patterns in the quadrants between the different subtypes of CP.
Alternative hypothesis: There will be a significant difference in the sensory modulation patterns in the quadrants between the different subtypes of CP.

Objective: Compare the quality of sensory modulation in the different sensory systems between the different subtypes of CP.

Null Hypothesis: There will be no significant difference in the different sensory systems between the different subtypes of CP.
Alternative hypothesis: There will be a significant difference in the different sensory systems between the different subtypes of CP.

Objective: Compare the behavioural responses associated with sensory modulation between the different subtypes of CP.
Null Hypothesis: There will be no significant difference in the behavioural responses associated with sensory modulation between the different subtypes of CP.
Alternative hypothesis: There will be a significant difference in the behavioural responses associated with sensory modulation between the different subtypes of CP.

1.7 SIGNIFICANCE/CONTRIBUTION OF THIS STUDY

The study aimed to bridge the gap in knowledge with regards to SMD in children with CP. More specifically, it sought to provide clarity as to whether different subtypes of CP present with different SMD or SMP. This knowledge will contribute valuable information to the overall clinical presentation of each subtype, which may have implications for the assessment, diagnosis and classification of CP.

Clinicians do not ordinarily assess sensory modulation in children with CP. Therefore, the study aimed to advocate for the use of sensory-based assessments, one of which being the SP2, as part of the holistic assessment of the child with CP. The results of the study will subsequently allow therapists to select appropriate intervention strategies, to treat the identified SMD.

Occupational therapists are concerned about how impairments affect the child's functional performance in all areas. Understanding the types of SMD and SMP occurring in the different subtypes will enable therapists to make suitable recommendations or adaptations in the home and school environment to allow children with CP to function more optimally. The knowledge acquired will support the development of specific sensory-based intervention programmes for children with CP.

The Bobath NDT approach is predominantly used to assess and treat children with CP. In NDT, occupational therapists work collaboratively with physiotherapists and speech therapists to evaluate and manage the child using a multidisciplinary approach.[80] Since SMD impact on other areas of functioning, such as motor and language development, the results of this study will also aid other therapists in their assessment and treatment of the child with CP.

1.8 SCOPE AND DELIMITATIONS OF STUDY

The study applies to occupational therapists, especially those working in the paediatric field of occupational therapy. In particular, the results will apply to occupational therapists working with children with CP. The study involves the assessment of sensory modulation under the umbrella of SPD. It does not include other types of SPD, such as praxis or discrimination. Moreover, it does not include intervention; however, the assessment findings may impact on the intervention of the child with CP indirectly.

The study is grounded in the following theories and frameworks:

- **Sensory integration theory:** Ayres' SI theory is a holistic framework which examines behaviour and learning. It is based on various theories and concepts including, human development, neuroscience, psychology, and occupational therapy.[2,13] SI theory involves the interaction and integration of the different sensory systems (auditory, vestibular, proprioceptive, tactile, and visual), which result in complex behaviours and learning.[13] Adaptive responses occur as a result of successful integration and organisation and also allow for further integration.[13] Within SI theory, sensory-rich experiences are thought to cause changes in the nervous system, through neuroplasticity.[13] SI theory encompasses the assessment and treatment of various SPD. The study involves one component of SPD, namely SMD.
- **Dunn's Sensory Processing Framework:** Dunn's Sensory Processing Framework was developed by Winnie Dunn.[81-82] The framework describes the interplay between the neurological threshold continuum (high to low) and the self-regulatory strategy continuum (active to passive).[82] The intersection of these continua produces four sensory modulation patterns, namely, the seeking,

avoiding, sensitivity, and registration patterns. The interaction of these continua allows for the explanation of how children process and modulate sensory information. The framework can also be used to assist with intervention planning.

- **Ecology of Human Performance:** The Ecology of Human Performance framework emphasises the interdependent relationship between the person and the context/environment (cultural, temporal, social and physical factors), and how this relationship affects human performance and behaviour.[83] Essentially the individual cannot be seen without considering the context. The SP2 encompasses many of the concepts in this model. Every individual is seen to have a unique sensory profile depending on various factors such as their genetics, experiences, environment, culture, and personality factors.[7,82,84] In the same way, every child with CP presents differently depending on various factors. The subtype of CP, the onset of the insult, and the severity of the insult will influence the clinical presentation of the child.[85] External factors, such as access to medical and therapeutic interventions, the availability of assistive devices, the accessibility of the environment, as well as social and cultural stigma may further impact on the child's functioning. The purpose of the study was not to examine all the contributing factors; however, the researcher did consider the impact of selected factors when interpreting the results.

1.9 ASSUMPTIONS

As stated above, there is contention regarding whether the theory of SI can be applied to children with CP. Sensory modulation is thought to be caused by dysfunctions in the central processing of sensation; therefore, involving the subcortical regions of the CNS.[2,72] While children with CP present with SMD, the causal mechanisms are different to TD children. In CP, damage occurring within the cortical regions of the CNS cause the observed SMD behaviours; whereas, in TD children, the subcortical regions are involved.[2] The theory of SI is considered to be dynamic, and it has subsequently evolved over the years. It has been applied to several diagnositic groups, including ASD and ADHD. The researcher assumed that although the cause of SMD may be different, the observed behaviours can still be examined using the SP2.

Sensory modulation is a neurological process, which cannot be directly measured. Therefore, SMD are identified based on the child's behavioural responses to sensory stimuli.[10] This study assumed that the SP2 could measure the frequency and intensity of the behaviours associated with SMD.[21]

1.10 DEFINITION OF KEY TERMS

Cerebral Palsy

"Cerebral palsy (CP) describes a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing foetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, perception, cognition, communication, and behaviour; by epilepsy, and by secondary musculoskeletal problems".[85(p572)]

Ataxic CP

A subtype of CP that presents with a loss of orderly muscle coordination, i.e. abnormal force, rhythm and accuracy; gait and trunk ataxia; tremors; and low muscle tone.[86]

Dyskinetic CP

A subtype of CP characterised by involuntary, uncontrolled, recurring and sometimes stereotypical movement, as well as fluctuating muscle tone. It is further subdivided into dystonia (associated with abnormal postures, hypokinesia and hypertonia), and choreoathetosis (associated with hyperkinesia and hypotonia).[86]

Spastic CP

A subtype of CP presenting with increased muscle tone and pathological reflexes. It is further subdivided into quadriplegia (involvement of all four limbs), diplegia (lower limbs involved more the upper limbs), and hemiplegia (one side involved more than the other side).[86]

Sensory modulation

Refers to the physiological and behavioural processes within the central nervous system (CNS) which regulate and grade responses to sensory stimulation from the environment and the body in an adaptive and appropriate manner, in order to meet the challenges in daily life.[2-4]

Sensory modulation disorder

A type of sensory processing disorder characterised by the impaired ability to adequately modulate different types of sensory stimuli, resulting in significant challenges in daily activities and routines. There are three recognised subtypes of sensory modulation disorders, i.e. sensory over-responsivity, sensory under-responsivity and sensory seeking.[2,4,16,26]

Sensory modulation patterns

Sensory modulation patterns (SMP) refer to the four quadrants in the Sensory Profile 2, i.e. seeking (also known as seeker), avoiding (avoider), sensitivity (sensor), and registration (bystander). SMP describe the relationship between neurological thresholds (high to low) and self-regulatory behaviours (passive to active). Each distinct pattern describes the distinct manner in which a person behaves in response to sensory input.[7,82]

Sensory systems

Refers to the sensory systems of the Sensory Profile 2, i.e. auditory, visual, touch (tactile), movement (vestibular), body position (proprioceptive), and oral sensory processing.

Behavioural systems

Refers to the behavioural responses associated with sensory processing that are identified in the Sensory Profile 2, i.e. conduct, social-emotional, and attentional responses.

SP2 bands

The Sensory Profile 2 converts the total raw scores into different bands based on the mean and standard deviation (Sd).[82] These bands occur on a bell curve. The bands are: Much Less” (-2Sd), “Less Than (-1Sd), “Just Like”, “More Than” (+1Sd), and “Much More” (+2Sd).

1.11 LAYOUT OF THE STUDY

The report contains the following chapters:

Chapter 1: Consists of an introduction and background to the study.

Chapter 2: Contains a literature review of the following constructs relevant to the study, i.e. classification, aetiology, prevalence, and associated impairments related to CP; sensory modulation theory and assessment; and application of sensory modulation in children with CP.

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

Chapter 4: Includes the results of the study with regards to the research objectives.

Chapter 5: Consists of a discussion of the findings as portrayed in chapter four.

Chapter 6: Critically evaluates the study, discusses the implications of the study, provides recommendations for future research, and provides an overall conclusion on the study.

1.12 SUMMARY OF INTRODUCTION

Chapter one aimed to establish the context, background, as well as the importance of the study. The chapter included the problem statement, research question, aim, objectives, and hypotheses of the study. The researcher discussed the significance of the study, as well as the assumptions, scope and limitations. The definitions of the important terminologies were also provided. Lastly, a layout of the research report was provided. Chapter two, the literature review, provides an overview of the literature and research related to the constructs of CP and sensory modulation.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

Chapter two is a review of the most pertinent literature available pertaining to the research topic. The literature review will consist of three main sections which are relevant to the aim and objectives of the study. The first section will look at the definition, classification, prevalence, aetiology, pathogenesis, as well as the impairments associated with CP. The second section will discuss sensory modulation theories and models, disorders of sensory modulation, the impact of SMD on behaviour and function, and lastly the assessment of SMD. The last section will bring the two concepts together, looking at sensory modulation disorders in CP, as well as the assessment of sensory modulation in children with CP.

The following databases were used to conduct the literature review: CINAHL: Cumulative Index to Nursing and Allied Health Literature, MEDLINE (Ovid), OTseeker and PubMed. A further search was conducted using Google Scholar and WorldCat through the University of Pretoria library. The searches included all articles and abstracts between 1990 and 2018 which were relevant to the study. The keywords used in the search included: ‘cerebral palsy’, ‘sensory processing’, ‘sensory modulation’, ‘sensory modulation patterns’, ‘sensory modulation disorders’, ‘assessment’, and ‘sensory profile’.

2.2 CEREBRAL PALSY

This section will discuss CP with regards to the definition, classification, aetiology and pathogenesis, prevalence and associated impairments.

2.2.1 Definition

Cerebral palsy refers to a group of neurodevelopmental disorders which are characterised by motor impairments, resulting from damage to the developing brain during the pre-, peri-, or post-natal period.[85,87] The manifestation of CP differs significantly depending on the aetiology, area and severity of structural damage, as well as the type and severity of functional and associated impairments; making the condition difficult to define.[1]

William Little originally described the condition in 1843. He hypothesised that the cause of spasticity and paralysis were related to brain damage occurring during the delivery of the infant.[88-89] Due to insufficient information at the time, researchers relied on the clinical presentation of the child and their speculation to define and describe CP. The definition of CP has evolved as research and medical technology has advanced. In the 1990's, Mutch and his colleagues emphasised the heterogeneity of the condition in their definition.[90] The most current and widely adopted definition of CP was defined by the Executive Committee for the Definition of Cerebral Palsy as:

> "a group of disorders of the development of movement and posture causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing foetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, cognition, communication, perception and/or behaviour; and/or by a seizure disorder".[85(p 572)]

Although there is much resemblance to the earlier definition by Mutch, the new definition incorporates the associated impairments which accompany the CP disorder. The inclusion of the associated impairments to the definition was vital, as they contribute to the overall clinical picture of the child with CP. In some cases, the associated impairments can even impose more severe functional limitations than the motor impairments.[1] Occupational therapists are particularly concerned about the child's functional abilities; therefore, this inclusion has significant implications for the assessment and treatment of the child with CP within the scope of occupational therapy. Furthermore, it is important to highlight that the definition also mentions the occurrence of sensory deficits, indicating that these should also be evaluated. Critics have argued that the definition neglects the progressive musculoskeletal pathologies associated with CP, including muscle contractures, bony torsion, hip displacement, spinal deformity, and degenerative arthritis.[91-92]

Central to the definition of CP are the following concepts: 1) it is an umbrella term for a group of disorders; 2.) it is permanent but not unchangeable; 3.) it refers to movement and/or posture disorders, which also affects motor function; 4.) it is caused by a non-progressive brain lesion or abnormality; and 5.) it occurs in the developing brain.[86,90,93-94]

2.2.2 Classification

The definition of CP only describes the cause and clinical picture of the condition. Due to the complexity of the condition, there are different categories or subtypes. Previously the classification was based on only the predominant tonal pattern and the areas of the body affected. Several factors are now recognised when classifying a child with CP, for example, the pathophysiology, neuroimaging studies, tonal patterns, motor impairments, topographical areas, associated impairments, as well as the functional mobility of the child.[85,86,95-96]

In the last 20 years, there has been a drive towards developing global CP surveillance registers. Although several countries have surveillance registers, the inclusion criteria and methods of classification vary between regions. Achieving consensus among regions on what constitutes inclusion and exclusion into these surveillance registers is critical for researching trends over time, as well as for intervention purposes.[94] The Surveillance of Cerebral Palsy in Europe (SCPE) is a collaboration of registers of children with CP in Europe.[86] The SCPE have attempted to standardise the definition and classification of children with CP, as well as provide specific inclusion and exclusion criteria for the diagnosis of CP, to allow for consistency in their surveillance. The inclusion and exclusion process, also known as the “decision tree”, is a process whereby the researcher or clinician answers a series of questions to confirm the diagnosis and determine the classification of CP.[86]

When diagnosing a child with CP, it is imperative to determine whether there is a movement or postural disorder present. The origin of the movement disorder must originate centrally, that is, from damage to the CNS. Furthermore, it should be non-progressive; therefore, conditions with a changing or worsening pattern do not meet the criteria.[94] Neuroimaging studies are regarded to be useful diagnostic tools to identify non-progressive lesions, as well as to determine the aetiology.[39] This tool, although valuable, is not easily accessible or affordable in developing countries.[76]

Cerebral palsy usually manifests early as delayed motor development with abnormal movement, tone or posture and persistent reflexes.[97] Diagnosis can be challenging, especially in the early years as the clinical picture can change.[94] The age of diagnosis varies in the literature between two and five years old.[87,93] In some cases, the symptoms present early on, especially in more severe types, and diagnosis can be made early; however, a later diagnosis is preferred to rule out the presence of changing neurological symptoms.[94] The SCPE recommends a confirmed diagnosis between the age of four-to-five years old for inclusion into the register.[86] A diagnosis is usually confirmed following a medical history, as well as a neurological examination.[87] Cerebral palsy is characterised by an insult to the developing brain in the first two years of life; thereafter, it is termed postnatally acquired CP or paediatric brain injury.[94,97] The age that postnatal causes are still considered to fall under the CP umbrella remains unclear internationally,[75] varying from two-to-eight years old.[76,94] A working group within the African Child Neurology Association, proposed that two years old should be the upper age limit.[76]

Once the diagnosis of CP is confirmed, the clinician or researcher can identify the primary neuromotor abnormality and the tonal distribution pattern. Cerebral palsy can be broadly categorised into two physiological groups, which include the "pyramidal" and the "extrapyramidal" types.[89] Spastic CP is associated with damage to the pyramidal tracts, resulting in upper motor neuron signs, weakness, increased muscle tone, reflexes, and clonus.[89,98] Dyskinesia and ataxic CP involve the extrapyramidal areas of the CNS.[89,98]

Although other classifications include the mixed and hypotonic subtypes, the SCPE describes three main subtypes of CP, namely, spastic, dyskinetic, and ataxic.[99] These subtypes are determined based on the classification tree, which is illustrated in figure 2.1 below. The dyskinetic subtype, characterised by involuntary movements and varying muscle tone, is further subdivided into the choreoathetotic and dystonic CP subtypes.[99] Although these are divided, clinically children with dyskinetic CP frequently present with a combination of choreoathetosis and dystonia.[100-101] The ataxic subtype is not subdivided.

Many clinicians or researchers use the topographical distribution or limb involvement to distinguish the spastic subtypes.[93] The spastic CP subtype is usually subdivided into spastic quadriplegic CP, referring to the involvement of all four limbs; spastic diplegic CP, referring to bilateral lower limb involvement; and spastic hemiplegic CP, referring to unilateral upper and lower limb involvement.[89] However, the SCPE classification divides the spastic CP subtype into unilateral spastic CP, which is equivalent to spastic hemiplegic CP; and bilateral spastic CP, which incorporates both spastic diplegic CP and spastic quadriplegic CP. The use of functional scales, such as the Manual Abilities Classification Scale (MACS) and the Gross Motor Functional Classification System (GMFCS) are recommended to discriminate between the spastic quadriplegic and diplegic subtypes.[86] If the child presents with a mixed presentation, the dominant pattern is preferred when classifying the child; however, the other patterns will be noted.[93]

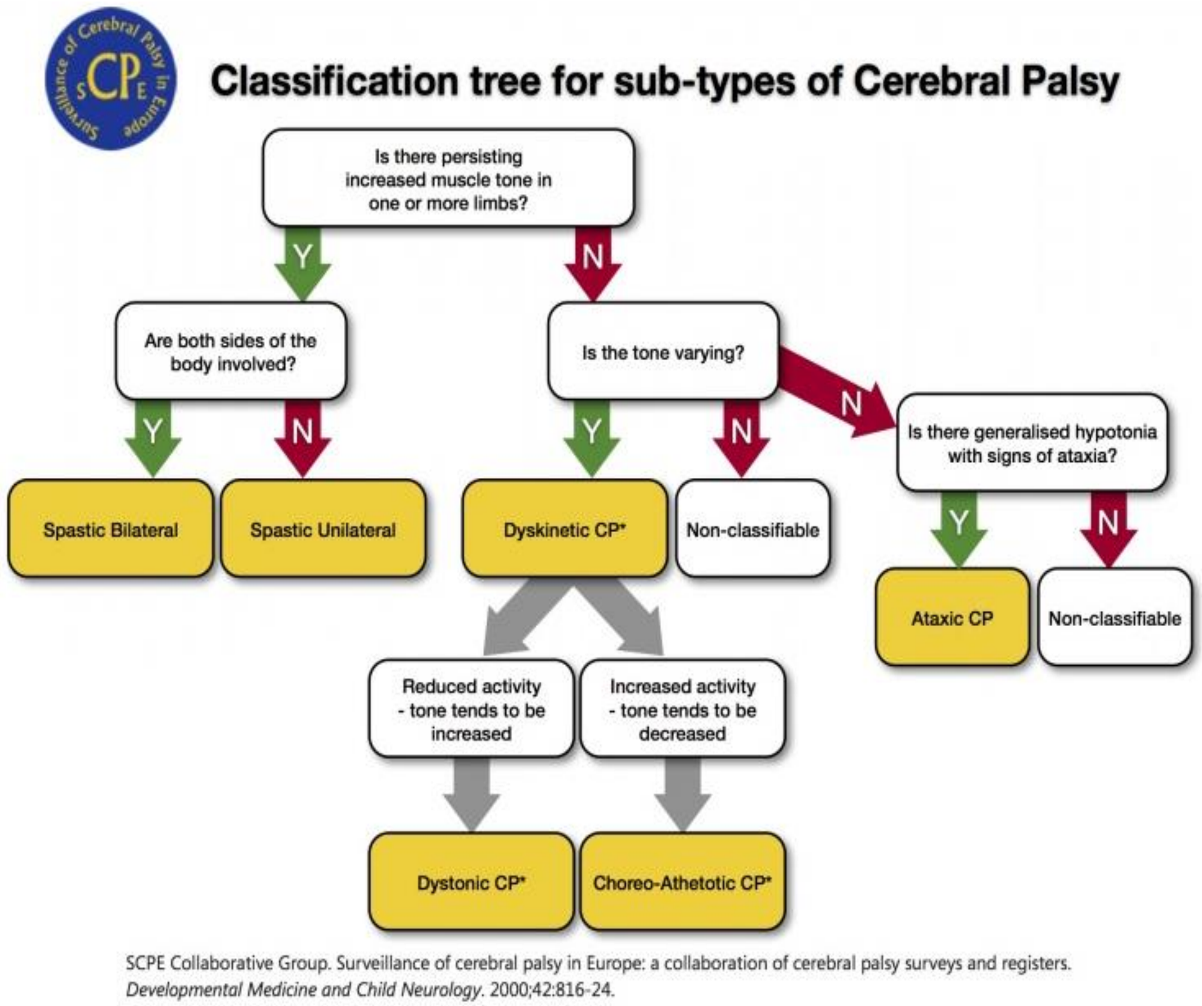


Figure 2.1 SCPE Classification tree[99]

Following the classification of CP, the severity of the motor function and the presence and severity of associated impairments needs to be determined. Historically, the health condition has been the focus of research and intervention. However, since the adoption of the International Classification of Functioning, Disability and Health (ICF) by the World Health Organisation, there has been a shift in focus to the functional consequences of health conditions.[85] As a result, the term "disability" has been replaced by the term "activity limitation".[85] Within this model, the body structures and functions, activity, participation, as well as the environmental and personal factors are thought to interact dynamically with the health condition (figure 2.2).[102]

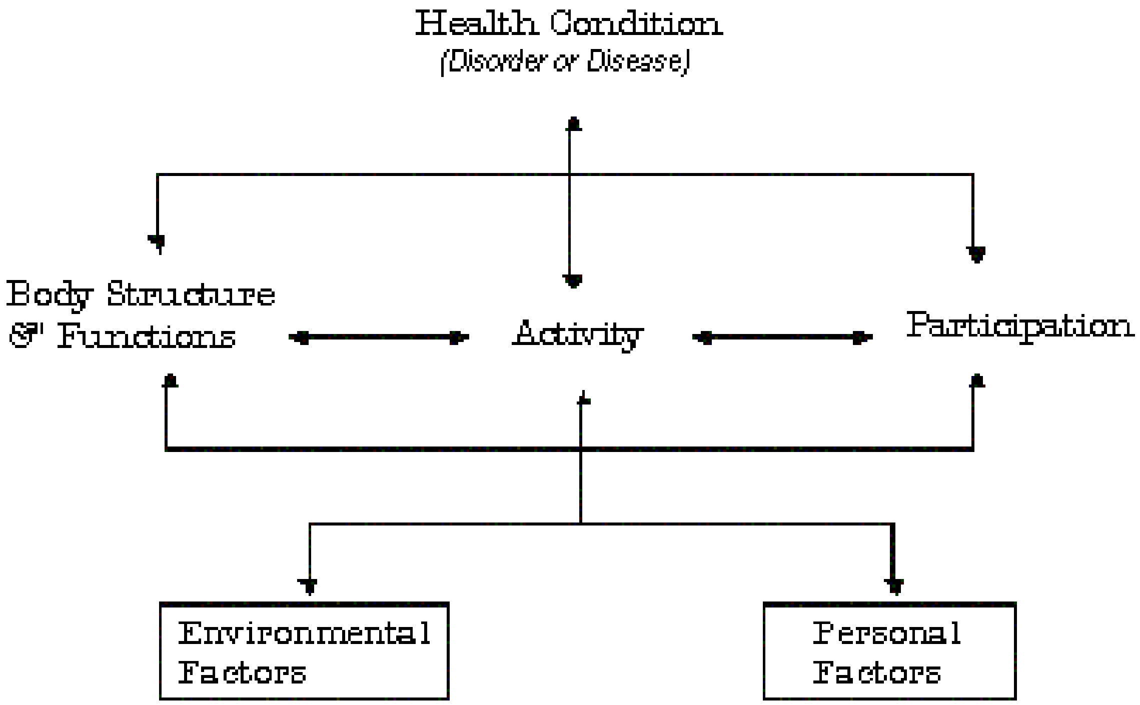


Figure 2.2 ICF model[103]

With more importance being placed on function, rather than dysfunction, the use of functional tools in the classification of CP has become essential. The GMFCS, a well-known and internationally recognised classification tool, was developed as a method of classifying children with CP into levels based on their gross motor abilities and limitations.[95,104] It is considered to be a simple, valid, and objective classification method which can be used reliably by professionals, without requiring additional training.[95] The five levels of functioning (I to V), take the child's ability to move independently into consideration, with the emphasis on sitting, standing and walking. There are four age groups, less than two years, two-to-four years, four-to-six years, and six-to-twelve years; thereby, reflecting the child's developmental stages.[95]

Within the GMFCS classification system, the severity of motor impairments increases as the GMFCS level increases. Therefore, children classified as functioning on level V have the most severe motor impairments and children classified as functioning on level I have the least severe motor impairments. Children classified as functioning on GMFCS levels I-III are ambulatory in varying degrees and qualities; whereas children classified as functioning on levels IV-V are predominantly non-ambulatory, and have more pronounced mobility limitations.[95] The levels are broadly defined as:

- **GMFCS level I** refers to children who can walk independently.
- **GMFCS level II** refers to children who can walk with some limitations (for example, long distances or stairs may be challenging).
- **GMFCS level III** refers to children who walk with a hand-held mobility device, such as a walker or a crutch.
- **GMFCS level IV** refers to children who may be able to walk short distances with assistance, but they predominantly use a manual or powered wheelchair.
- **GMFCS level V** refers to children who require a wheelchair in all settings.[95]

In summary, the continuously evolving knowledge base attributed to medical and technological advancement, as well as the growing popularity of the ICF has influenced how children with CP are classified. Classification should be multidimensional and consider the primary and secondary tone abnormalities, brain imaging results, anatomical distribution, the functional abilities in the upper and lower limbs, and the associated impairments.

2.2.3 Aetiology and pathogenesis

The aetiology of CP is multifaceted and includes genetic, congenital, inflammatory, infectious, anoxic, traumatic and metabolic causes, which may occur pre-, peri- or postnatally.[98] The pathogenesis of CP includes both axonal and neuronal deficits in the white (myelinated axons and tracts) and grey matter (neuronal cell bodies) structures in the cerebral cortex; decreased thalamocortical connections; and the loss of subcortical structures, including the thalamus, basal ganglia, brainstem and cerebellum.[46-47,50]

Imaging studies can detect the onset of the lesion. A study done by Ashwal (2004), reported that the onset occurred prenatally in 37% of cases, perinatally in 35% of cases, and postnatally in 4% of cases; therefore, supporting the notion that the cause of insult occurs predominantly before or during birth.[87] Prenatal risk factors include: intrauterine infections, toxic exposure, multiple births, strokes and placental abruption.[87,98] Perinatal risk factors include: infections, intracranial haemorrhage, strokes, hypoxic-ischemic encephalopathy, kernicterus and trauma.[87,98] Postnatal causes include: meningitis, encephalitis, strokes, progressive hydrocephalus and traumatic brain injuries, such as near-drownings.[87,98]

The advancement in neuroimaging studies has also allowed researchers to identify the predominant causes of CP in approximately 83% of cases using magnetic resonance imaging (MRI) scans.[39] MRI scans indicate that bilateral spastic CP is strongly associated (60% of cases) with periventricular white matter lesions; whereas, cortical lesions and brain malformations are less frequent, occurring in 15% and 10% of cases respectively. Brain malformations (16%), periventricular white matter lesions (36%), and cortical or deep grey matter lesions (31%) were found in spastic unilateral CP. Cortical or deep grey matter lesions accounted for the majority (54%) of the dyskinetic CP subtype (born at full term), with periventricular white matter lesions only occurring in 14% of cases. Pure dyskinesia is associated with basal ganglia and thalamic lesions in the more premature child. Imaging studies are done less frequently in the ataxic group; however, 17% of children presented with cerebellar malformations and 17% presented with no lesions.[39]

White matter injuries are associated with prematurity, with 67-79% of scans reflecting white matter injuries in children born before 34 weeks.[105] The somatosensory tracts and pyramidal white matter tracts mature early on and are; therefore, they are vulnerable to injury.[49] In contrast, MRI scans predominantly portray grey matter injuries (21%), focal vascular insults (12%) and malformations (13%) in children born after 37 weeks.[105] White matter injuries are common to all CP subtypes; however, children with spastic diplegia have the highest prevalence (31-61%). Grey matter injuries are more frequently associated with spastic quadriplegia (34%) and dyskinesia (21%).[105] Focal vascular insults are most prevalent in the spastic hemiplegic subtype (24%).[105]

The predominant aetiology varies between developed and developing countries.[106] Prematurity and low birth weight is the major cause in developed countries; while birth asphyxia, kernicterus, and neonatal infections contribute to the primary causes in Africa.[76,106-107] Within the African context, children born prematurely or with a low birth weight are less likely to survive; therefore, there are lower percentages of CP attributed to prematurity and low birth weight in comparison to developed countries.[76,107] Albeit that CP commonly occurs during or shortly after birth, there are a higher number of acquired (postnatal) CP cases in Africa due to secondary postnatal complications, such meningitis, encephalitis, cerebral malaria, and traumatic brain injuries.[76,108]

2.2.4 The prevalence

A recent systematic review and meta-analysis of 49 studies on CP, reported a pooled prevalence of approximately 2-2.11 per 1000 live births globally.[109] This prevalence has remained relatively stable despite the advancement in medical intervention and prevention strategies, such as antenatal corticosteroids, cooling in asphyxiated term births, and the use of magnesium sulphate.[109] This observation is seemingly due to the increase in survival of premature infants, which are at a higher risk of developing CP.[109] Cerebral palsy occurs more frequently in males, with male-to-female prevalence ratios approximately 1.4:1.[110-111]

As mentioned previously, the primary risk factors associated with CP, especially in developed countries, are low birth weight and prematurity.[39,98,109] A birth weight of less than 1000g is defined as extremely low birth weight (ELBW); a birth weight of less than 1500g is defined as very low birth weight (VLBW); birth weights between 1500g and 2500g are defined as low birth weights (LBW); and a normal birth weight (NBW) is defined as a being more than 2500g.[112] The prevalence of CP is highest in those in the VLBW bands (59.18 per 1000 births) and lowest in those in the NBW bands (1.33 per 1000 births).[39,109] In CP cases, 20% are born prematurely between 32-36 weeks, and 25% are born very prematurely at less than 32 weeks.[39] Although the majority of children with CP (55%) are born at full term,[39] the higher percentage is due to the higher frequency of overall term births, rather than due to outright risk.[98] From the gestational bands, the prevalence was highest in those born before 28 weeks (111.80 per 1000 births), compared to those born at 36 weeks, where the prevalence was 1.35; reflecting that the incidence of CP decreases with increased gestational age.[39,109]

There is a paucity of information with regards to the prevalence of CP in African countries, including South Africa;[76] however, studies have found significantly higher proportions of CP in African in comparison to developed countries.[113-114] The South African National Census (2011) reported a high prevalence of disability in childhood; whereby 10.8% in children five-to-nine years, 4.1% in children ten-to-14 years, and 2.6% in children aged 15-19 years old are reported to have a disability.[115] According to a 2012 situational analysis report, the estimated number of children with a disability was 2.1 million; however, this number was reported to be underestimated, and therefore these numbers can be assumed to be higher.[77] A study conducted by Couper (2002) in rural Kwa-Zulu Natal, found the prevalence of CP to be 10 per 1000 births (1%), five times higher than in developed countries.[113] Christianson et al. (2002) found that 8.2% of children with intellectual disability presented with CP.[114] Factors contributing to this high prevalence of disability and CP include socio-economic status, as well as inadequate obstetric care.[113]

Within the different CP subtypes, the prevalence also varies in the literature. From the SCPE database (n=4792), spastic CP accounted for 85.7% of the cases, with 54.9% presenting with bilateral spastic CP (1.16 per 1000 births), and 29.2% with unilateral spastic CP (0.6 per 1000 births).[111] Dyskinesia (6.5%) and ataxia (4.3%) were the least prevalent subtypes, with 3.3% of cases unclassifiable.[111] In Victoria, Australia, 86.4% of cases were spastic CP, 1.5% of cases were dyskinetic CP, 2.8% of cases were ataxic CP, and the rest were mixed and hypotonic.[116] A local study done at Tygerberg Hospital, in South Africa, found the prevalence of spastic CP to be approximately 81%, with dyskinesia and ataxia accounting for 7.4% and 1.2% respectively.[108] Spastic quadriplegia occurred in about 40.1% of the cases, and spastic diplegia occurred in 14.5% of the cases; therefore, reflecting similar percentages (54.6%) of bilateral spastic CP to the SCPE data.[108] Unilateral spastic CP (hemiplegia) accounted for

26.4% of the cases in Tygerberg, slightly lower than the SCPE data.[108] Generally, the spastic subtype accounts for approximately 70-80% of CP cases, the dyskinetic subtype accounts for 10-20% of CP cases, and the ataxic subtype accounts for 5-10% of CP cases.[97]

Geographically, a strong correlation exists between the aetiology and the prevalence of the subtype of CP.[106] White matter injuries (associated with spastic diplegia and premature births) occur in 19-45% of cases in developed countries, as opposed to only 4% in developing countries.[105,117-118] On the other hand, grey matter injuries (associated with spastic quadriplegia and dyskinesia) occur in 14-22% of cases in developed countries, with 44% in developing countries.[105,117-118] Spastic quadriplegia is reported to be the predominant subtype of CP in developing countries, which can be attributed to the high prevalence of severe birth asphyxia and acquired infections.[106,108] Contrastingly, the high occurrence of spastic diplegia in developed countries can be attributed to the increased survival of extremely premature infants and multiple births.[106,109]

Researchers in Victoria compared the distribution of GMFCS levels in the different topography groups.[116] Children with spastic hemiplegia were found to be less severe, with 81% classified as functioning on GMFCS I; while children with spastic quadriplegia had the lowest levels of functioning, with 83% falling in the GMFCS IV-V categories. There were relatively similar distributions of the children with spastic diplegia in the GMFCS levels I-III groups. The findings in a Nigerian sample (n=100) were similar, whereby 76% of children with spastic quadriplegia were either classified as functioning on GMFCS level IV or V, and all the children with spastic hemiplegia were ambulatory (GMFCS levels I-III).[119] The prevalence of CP within the different GMFCS levels also varies between regions. In Victoria, 35.3% were classified as functioning on GMFCS level I, 16.4% were classified as functioning on GMFCS level II, 14.2% were classified as functioning on GMFCS level III, 16.1% were classified as functioning on GMFCS IV, and 18.0% were classified as functioning on GMFCS level V; therefore, the majority were classified as functioning on GMFCS levels I-III. In comparison, there seems to be a higher incidence of GMFCS levels IV and V (46-58%) in African countries.[107,119] Secondary impairments which are caused by delays in diagnosis or lack of intervention, may contribute to the increased severity in motor function observed in Africa.[76]

2.2.5 Associated impairments

The motor impairments are frequently accompanied by various non-motor impairments, as highlighted in the definition of CP. These can impose more significant restrictions on activity participation than the motor impairments.[85] Cognitive impairments are the most commonly associated with CP, occurring in approximately 30-65% of cases.[89,98] There is a correlation between the severity of the spastic motor impairment and the degree of cognitive deficit, whereby children with spastic quadriplegia have a higher risk than children with spastic hemiplegia.[89] There is also a correlation between the presence of epilepsy, as well as abnormal neuroimaging findings and cognitive impairments. Epilepsy occurs in 20-60% of children with CP, occurring more frequently in children with quadriplegia (19-36%) and hemiplegia (28-35%), and less in children with diplegia (14%), ataxia (13-16%) and dyskinesia (8-13%).[89,98] A recent study done in Botswana reported cognitive impairments in 82% of subjects, and epilepsy in 76% of subjects; reflecting a higher prevalence of associated impairments within the African context.[107] Speech impairments, including dysarthria and aphasia, are related to the type and severity of the motor impairments.[89,98] Children with CP may also present with articulation disorders or poor intelligibility. Difficulties with language are commonly associated with cognitive deficits.[89]

Visual acuity deficits occur in more than 70% of children with CP, with the majority presenting with cortical visual impairments. Other visual difficulties include strabismus, nystagmus and amblyopia.[89] Furthermore, visual deficits are more prevalent in those born prematurely.[89] Hearing impairments are less prevalent, occurring in approximately 2-12% of children, especially in those with ELBW or VLBW, neonatal meningitis and severe hypoxic-ischemic insults.[89,98] Approximately 40-50% of children with CP have somatosensory deficits due to CNS damage, especially children with hemiplegia.[89] Feeding, growth and urogenital problems also occur frequently in the CP population.[89]

Secondary changes are characteristic in children with CP, especially in older children or adolescents.[92] These changes are related to both neural (tone, clonus, hyperreflexia and co-contraction) and mechanical (weakness, sensory deficits, fatigability, poor balance) mechanisms, which can both contribute to the secondary musculoskeletal changes.[92] These secondary changes may impede the child's mobility and wellbeing.

There is a correlation between the number of impairments and the severity of the GMFCS level, whereby the GMFCS level increases with increasing number of associated impairments.[119] Therefore, it is crucial to consider these impairments as they have a significant impact on the functional status of the child.

Cerebral Palsy is a heterogeneous disorder, primarily recognised for its motor impairments. Recent research has emphasised the importance of considering the sensory impairments which accompany the motor impairments. Occupational therapists assess and treat sensory impairments using biomechanical and sensory integration frameworks. Since the study is concerned with the sensory modulation patterns in children with CP, the next section will discuss relevant theory and literature pertaining to sensory processing, integration and modulation.

2.3 SENSORY PROCESSING

2.3.1 Introduction to sensory integration

The concept of sensory integration (SI), pioneered by Dr Jean Ayres in the early 1960's, is well recognised amongst occupational therapists. Ayres defined sensory integration as "the neurological processing that organises incoming sensation from one's own body and from the environment and makes it possible to use the body effectively within the environment."[72(p11)] The term sensory integration disorders was coined by Ayres to describe the behaviours associated with poor sensory integration.[6] These disorders, including, bilateral integration and sequencing disorders and praxis disorders are assessed using the Sensory Integration and Praxis Tests (SIPT).[120]

The treatment of sensory integration disorders is known as Ayres Sensory Integration® (also referred to as ASI). ASI® intervention is based on an accepted fidelity measure[121] and involves: improving the child's ability to process and integrate sensory information, achieving optimal postural control through whole body movements, as well as providing opportunities to challenge praxis and make an adaptive response. Occupational therapists achieve this through engagement in sensory-rich (especially recruiting the vestibular, proprioceptive and tactile systems), child-directed, and intrinsically motivating activities.[2,6,13,121] Sensory-based activities may or may not be considered ASI® depending on whether they meet the requirements of the fidelity measure.[6,121]

2.3.2 Sensory processing

2.3.2.1 Neurophysiology of sensory processing

Sensory processing is an umbrella term encompassing all the processes involved in managing sensory information within the nervous system, including the registration and modulation of sensory information.[10] The processing of sensory information is a complicated process occurring at different levels within the peripheral nervous system and CNS, starting with the registration of a stimulus and ending with the response generated for that input.[1-2,122] Cellular sensory processing occurs within the peripheral nervous system in the seven sensory systems (tactile, proprioceptive, vestibular, visual, auditory, gustatory, and orofactory), and involves the reception and transmission of the input to the CNS.[1] The processes that occur within the CNS include the reception, modulation, integration and organisation of sensory stimuli.[1] ASI is concerned with mainly the vestibular, proprioceptive and vestibular systems, referred to as the primary sensations.[6,13]

Somatosensory information is transmitted to the CNS in white matter tracts, including the dorsal column-medial lemniscal (DCML), the anterolateral and the trigemino-thalamic tracts.[2] The DCML predominantly transmits mechanical stimuli, that is, tactile, vibratory, touch-pressure, proprioceptive and temporal and spatial aspects of a stimulus. The DCML has a role to play in tactile discriminatory functions, such as the perception of size, form and contour, texture and movement across the skin via the large fibres.[2] The anterolateral system is composed of separate pathways that function primarily to mediate pain, light touch and crude touch, as well as neural warmth and tickle.[2] The trigemino-thalamic pathway transmits somatosensory input from the face. The tract transmits information about pain, temperature and non-discriminative touch from the face and mouth to the CNS.[2]

The vestibular system consists of three semi-circular canals and two otolith organs, the utricle and saccule which reside in the inner ear. The utricle is responsible for the detection of linear, sustained (tonic) and low-frequency stimuli, that is, the stationary head position and head movements of less than two degrees per second.[2] The exact functions of the saccule are unclear, but it seems to influence the detection of vertical acceleration, notably gravity and anterior-posterior movement. Together the utricle and saccule detect head tilt in any direction, linear movement (acceleration and deceleration), the rate of linear movement, and the static position of the head in space.[2] The semi-circular canals are most efficient at detecting angular, transient (phasic) and high-frequency head movements occurring at less than two degrees per second.[2] The ascending and descending tracts of the vestibular system influence flexor and extensor muscles, the autonomic nervous system, arousal, compensatory eye movements, and the conscious awareness of body position.[2]

2.3.2.2 Sensory processing from an occupational therapy perspective

The sensory processing terminology used in SI literature is not unique to occupational therapists and is commonly used amongst other disciplines, such as neurologists. The definitions may vary depending on the intent; with researchers and scientists concentrating predominantly on the processes occurring in the brain, and occupational therapists describing the visible behavioural manifestations.[122] Since it would be impractical to place electrodes on the child's brain, occupational therapists rely on the observed behavioural manifestations to hypothesise what might be happening within the brain.[84] In occupational therapy literature and clinical practice, the terms sensory processing and sensory integration are often used interchangeably, despite them referring to different aspects. Sensory integration refers to one aspect of sensory processing, whereas sensory processing encompasses all the processes.[1]

In an attempt to provide clarity and consistency, Lucy Miller and her team proposed a new nosology. They suggested that the term sensory processing disorders (SPD) replace Ayres' term sensory integration disorders, to distinguish them from sensory integration theory, assessment and treatment.[4] Within this SPD framework, there are three different disorders (figure 2.3) which are:

- **Sensory-Based Motor Disorders** which relate to postural deficits, including dyspraxia and postural disorders;
- **Sensory Discrimination Disorders (SDD)** which relate to difficulties with interpreting the quality of sensory information, such as the location or identity;
- **Sensory Modulation Disorders (SMD)** which relate to difficulties grading and reacting appropriately to sensory information.[4]

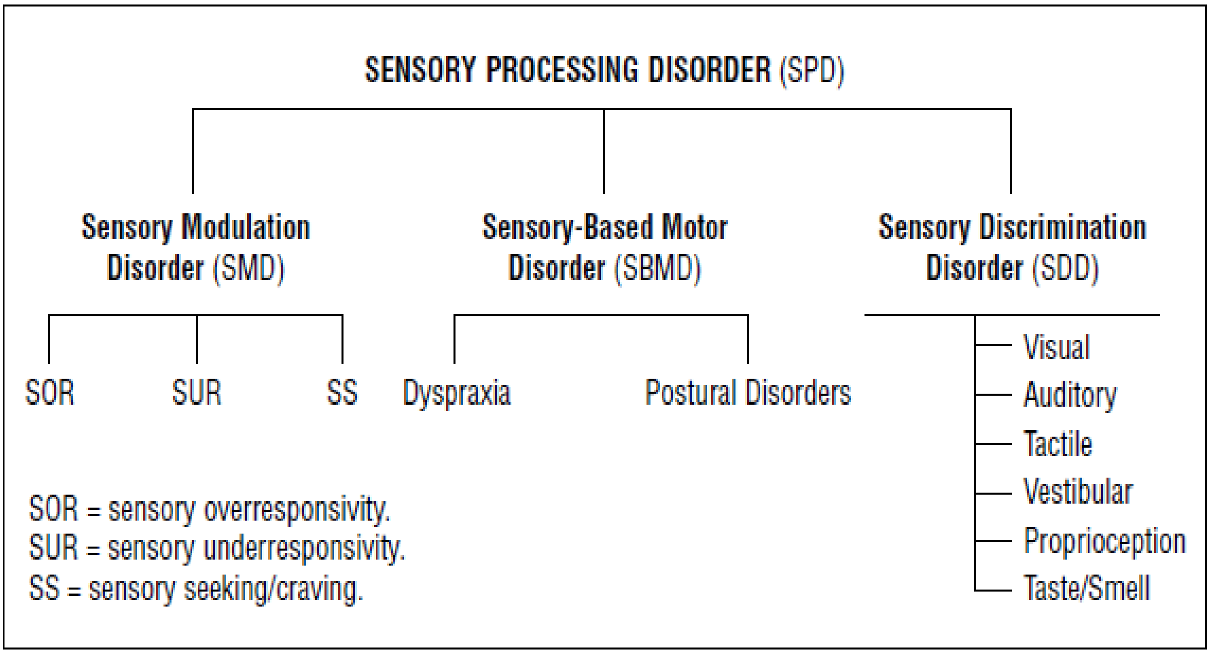


Figure 2.3 Proposed classification of SPD by Miller et al. (2007)[4]

Each one of the SPD represents different aspects of sensory processing within the CNS. SPD can involve more than one sensory system and a child may present with one or several disorders.[4] For example, a child could present with SMD in the tactile, and auditory systems, SDD in the vestibular and proprioceptive systems, and a postural disorder. The next section will discuss SMD in greater detail.

2.3.3 Sensory modulation

2.3.3.1 Neurophysiology of sensory modulation

Sensory modulation describes one specific aspect of the overall processing of sensory information. It refers to the ability to adapt, and appropriately regulate and grade responses to the sensory environment in a manner that is consistent with the demands of the situation.[4] This adaptability allows the child to cope with sensory challenges in daily activities. Sensory modulation plays a vital role in the functioning of the CNS and subsequently, in the child's ability to participate optimally in daily activities.[2,7] Factors influencing sensory modulation include genetics, experience, and the environment.[7] Each person is considered to have a unique "sensory profile", which is thought to remain relatively consistent over time.[7,84]

Sensory modulation is said to occur in three phases, namely:

- **Registration** which involves the perception of stimulus at receptor sites resulting in the transmission of the impulse to the CNS for processing;
- **Orientation** which refers to the evaluation of the importance of the sensory stimuli based on previous experiences (neuronal models); and
- **Arousal** which refers to the voluntary effort and attention required in preparation for the response to the stimuli.[123]

Within these phases, it is essential to discriminate between processes occurring within the CNS and the observable behaviours or the sensory modulation symptoms.[122] On a neurological level, modulation refers to the CNS's ability to regulate sensory stimuli with regards to the intensity, frequency, duration and novelty of the input; as well as the constant adaptation to changing sensory stimuli.[1,4] All neurons have a resting membrane potential which is responsive to the strength and duration of the sensory input it receives.[1] Once the neuron reaches a certain threshold, an action potential is generated, allowing for the propagation of the impulse signal along the neuron.[1] An under-responsive nervous system has a high neurological threshold and it requires a stronger or more intense input.[38,122] In contrast, over-responsive nervous systems have low neurological thresholds and respond rapidly to input, or require less input to propagate the action potential.[38,122] These thresholds are different from the behavioural neurological thresholds which will be described later.

Neuromodulation reflects two key cellular mechanisms of habituation and sensitisation. Habituation occurs when the nerve cells and CNS recognise that the stimulus is familiar, resulting in a decrease in the transmission of the input.[7,82,122] Habituation allows the child to focus on more important sensory information. When there is too much habituation, the child may be passive or unresponsive. Sensitisation occurs when the neurons become overactive, resulting in a heightened sensation or sensitivity.[7,82,122] In contrast to habituation; sensitisation allows the child to focus on things occurring in their surroundings. The enhancement or sensitisation of cells in the CNS may also be observed behaviourally as a defensive or withdrawal response. Appropriate modulation relies on the continuous balance between sensitisation and habituation.

The autonomic nervous system (ANS) plays a role in the modulation of sensory, motor, visceral and neuroendocrine functions, via the sympathetic (fight or flight responses) and parasympathetic branches (homeostasis).[8] These processes contribute to self-regulation and adaptability to internal and external changes in the environment.[8] Until recently, clinicians have relied on behavioural observations to assess ANS functioning. Pupil dilation, irregular breathing, flushing of the skin and yawning are indicators of sympathetic over-activation.[2] Recent neurophysiological evidence indicates that there may be a correlation between SMD and the ANS, especially in children with disabilities.[8,26,32,124] Studies have shown that children with SMD had elevated electrodermal responses and decreased habituation, which is associated with over-responsivity in the sympathetic nervous systems.[32,124] The parasympathetic branches also contribute to SMD; in particular, the disorganisation or diminished responsivity within this system may negatively affect the child’s ability to remain calm and self-regulate.[8]

The limbic system is referred to as a modulating centre for sensory input, playing an important role in attention and orientation.[2] There is some speculation that the structures in the limbic system are involved in sensory modulation by virtue of the functions of the different structures. The functions of the limbic system related to sensory modulation include the influence on the ANS, mood, emotion, as well as the memory of sensory experiences.[2]

Stress and anxiety can increase the child's level of arousal, which is influenced by both the limbic system and the reticular activating system (RAS).[2] Arousal, from a neurophysiological perspective, refers to wakefulness and consciousness, which is dependent on the RAS. The RAS occurs in the brainstem and has a role in regulating arousal and consciousness.[2] It receives input from the sensory pathways and projects to the cortex directly and via the thalamic nuclei. The RAS plays a role in filtering irrelevant stimuli to focus on the most critical sensory cues. New sensory information increases wakefulness due to the increase in activity in the cerebral cortex via the ascending pathways of the RAS.[2] When that sensory input is removed, the RAS is less active, and wakefulness gradually subsides.[2] The higher cortical structures including the hippocampus, hypothalamus and frontal cortex can influence the RAS via reciprocal pathways. The optimum level of arousal represents the level of neuron excitability required to remain focused on the task. Over-arousal has been linked to behavioural disorganisation, anxiety and a potentially harmful response or "shut down". Children who are under-responsive tend to be under-aroused.[2]

2.3.3.2 Sensory modulation from an occupational therapy perspective

Modulation from a behavioural perspective refers to the ability to regulate and grade responses in a manner that is appropriate and in direct proportion to the input.[1,3-4] An imbalance in these processes is observed as either over-responsivity (too much sensitivity or too little inhibition), or under-responsivity (too much inhibition or too little sensitivity), resulting in dysfunctional behaviours whereby the child is unable to regulate or adapt to changing environments.[3-4,7] A well-modulated nervous system adapts to changes in the environment, has an appropriate level of arousal and attention, habituates inappropriate input and attends to appropriate stimuli, and this response is in direct proportion to the input.[123] SMD are only diagnosed when the impairments significantly affect the child's daily functioning, usually in several areas.[4]

Miller et al. (2007) proposed three subtypes of SMD based on the different response patterns, that is, sensory over-responsivity (SOR), sensory under-responsivity (SUR), and sensory seeking (SS).[4] In sensory over-responsivity, the individual has a more significant or intense response to sensory input than those who can modulate the input adequately. It is often associated with a sympathetic “fight”, “flight, or “fright” response, such as nausea or flushing of the skin.[3,4] In contrast, sensory under-responsivity refers to a decreased or slower response to sensory input.[3] Sensory seeking reflects a craving to acquire additional or intense sensory experiences. A person’s response can also fluctuate between under- and over-responsivity.[3]

There has recently been a change in the terminology in the literature from “responsivity” to “reactivity”. This change appears to be associated to the terminology used in the diagnosis of ASD in the DSM-V, whereby they refer to “responsivity”. However, this change has not been universally adopted in the literature, with some authors still referring to “responsivity”. The researcher acknowledges that there has been a recent change in terminology; however, for the purposes of this paper, the terminology proposed by Miller et al. (2007) will be used.

Despite the fact that the concept of sensory modulation, as well as the treatment of SMD, has been recognised by occupational therapists for some time, it was only until recently, that research validating the concept has emerged.[2] Although Ayres’ work focused on praxis disorders, her early work also described some aspects of sensory modulation, namely tactile defensiveness with hyperactive-distractible behaviours, and gravitational insecurity.[6,72] Sensory modulation occurs within all sensory systems; however, four specific types of SMD exist in the literature:

- **Tactile defensiveness** relates to an autonomic response in response to unexpected light touch, due to a lack of inhibition of this input in the cortex.
- **Gravitational insecurity** is associated with over-responsivity within the vestibular-proprioceptive systems, resulting in an excessive emotional response to movement, due to insufficient modulation in the otolith organs.
- **Aversive responses to movement** are also associated with over-responsivity within the vestibular-proprioceptive systems, specifically within the semi-circular canals, resulting in nausea, vomiting or dizziness after movement.
- **Under-responsiveness** (also termed poor registration) is associated with decreased responsivity to stimuli.[2]

2.3.3.3 Models of sensory modulation

The literature describes several models relating to sensory modulation. Early models approached sensory modulation linearly; ranging from under-responsivity (or failure to orientate) on one end, and over-responsivity on the other end of the continuum.[12] The linear models did not explain the complexity of the process, which led to the development of more dynamic models.

The Ecological Model of Sensory Modulation subscribes to the belief that sensory modulation is interlinked, rather than linear.[32] Core to this model is the relationship between the internal and external factors, with SMD resulting from the interaction between several factors.[32] The factors include contextual factors (culture, environment, relationships and tasks) and individual symptoms (sensation, emotion and attention).[32] The child's responses are analysed within the context of their external life.

Dunn's Sensory Processing Framework (figure 2.4) is widely recognised among occupational therapists.[82] The framework is based on the premise that a relationship exists between the neurological processes and the observed behavioural responses.[7] The framework consists of two constructs which are thought to occur on a continuum.

On the vertical axis is the neurological threshold, ranging from high to low. Neurological thresholds in this model refer to the behavioural responses associated with the CNS responsivity; that is, a high threshold is related to an under-responsive CNS, and a low threshold is related to an over-responsive CNS.[82] Children with a high neurological threshold require a stronger sensory input before a behavioural response occurs. In contrast, a child with a low neurological threshold requires a less intense or less frequent stimulation before a behavioural reaction occurs.[38]

Self-regulation refers to the nature of the behavioural response and can be found on the horizontal axis, ranging from passive to active.[82] A child is categorised as passive if they do not actively respond or change their actions in response to a stimulus, thereby acting in accordance with the threshold.[7,82] On the other end of the continua is the active self-regulation strategy, whereby the child tries to control or change the sensory input to a level that meets their needs, thereby acting in a manner to counteract the threshold.[7,82]

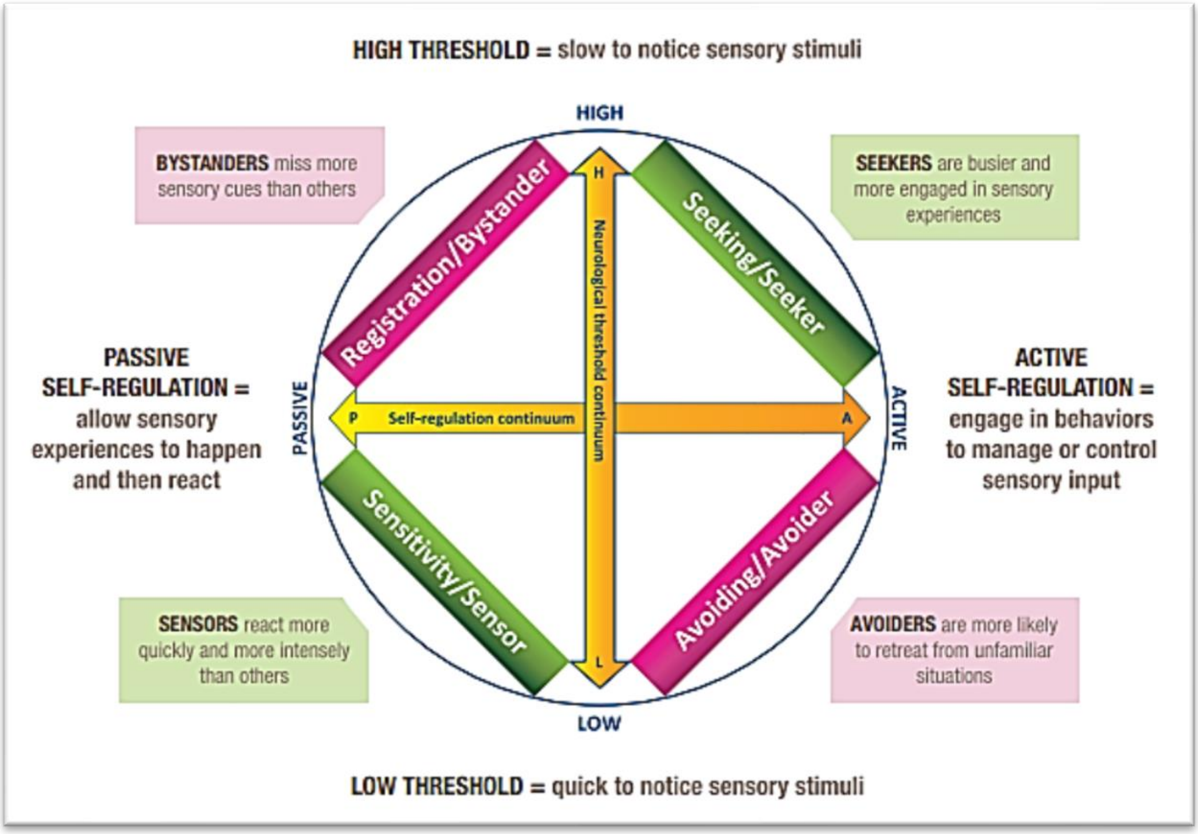


Figure 2.4 Dunn's Sensory Processing Framework[125]

When the vertical (neurological threshold) and horizontal (self-regulation) constructs intersect, they produce four patterns or quadrants of sensory modulation, namely seeking, avoiding, sensitivity, and registration.[82]

- **Seeking** is the outcome of a high neurological threshold and an active self-regulatory strategy. It pertains to the degree to which a child obtains sensory information. These children are also called "seekers".
- **Avoiding** is the outcome of a low neurological threshold and an active self-regulatory strategy. It pertains to the degree to which a child is bothered by sensory information. These children are also known as "avoiders".
- **Sensitivity** is the outcome of a low neurological threshold and a passive self-regulatory strategy. It pertains to the degree to which a child detects sensory information. Another term used to describe these children is "sensor".

- **Registration** is the outcome of a high neurological threshold and a passive self-regulatory strategy. It pertains to the degree to which a child misses sensory information. They are also called "bystanders”.[82]

Different researchers have reported different groups or clusters of SMD within the general population.[4,82,126] A recent study reported five distinct sensory subtypes based on the quadrant scores in Dunn’s Sensory Processing Framework. These patterns were observed in typical children, as well as in children with various disabilities. The five patterns or subtypes were defined as:

- **Balanced sensory profile:** is characterised by scores within the average range and reflects sensory difficulties that occur less frequently.
- **Intense sensory profile:** is characterised by concurrent high scores across the quadrant scores.
- **Vigilant sensory profile:** is characterised by high scores in the avoidant and sensitivity quadrants.
- **Interested sensory profile:** is characterised by sensory seeking behaviours, consistent with a significantly younger population.
- **Mellow until… sensory profile:** is characterised by higher scores in the avoiding and registration quadrants.[127]

Sensory modulation has been studied in many neurodevelopmental disorders, especially ASD and ADHD. While it is clear that children with disabilities are more likely to have SMD than TD children,[23,27,128] current research has focused on identifying whether specific patterns of sensory modulation occur in different diagnostic groups.[35] There is mounting evidence to suggest that different SMP occur within specific conditions.[20,22,25,128] Furthermore, researchers have found that different conditions present uniquely, which may have implications for the diagnosis of these conditions.[26,29-30]

2.3.3.4 Impact of sensory modulation on behaviour and function

It is essential to understand the neuroscience underpinning SI theory, as this provides a window into what is happening in the brain; however, occupational therapists are more concerned with the behavioural manifestations of abnormal sensory processing.

SMD can manifest differently with regards to the severity, manner and sensory systems involved.[2-3]

Despite the differences in terminology among researchers, there appears to be some consensus with regards to the behavioural patterns in each grouping. Sensory seekers tend to engage in some or all of these behaviours significantly more than their peers. They may look for opportunities to get more feedback; be on the go or fidget; touch/chew things; make noises while they work; take more risks when playing; become excited during movement; or struggle to concentrate or sit still for long periods of time. Sensory avoiders may be bothered by things that others do not notice; be more withdrawn or play on their own; avoid unfamiliar situations or sensory inputs that they do not like; be bossy or controlling; or they may become very upset when things do not go according to plan. Sensors react quickly and more intensely to sensory information than others; they pay more attention to detail; they struggle to block out unessential sensory input, which causes them to become easily distracted; or they may be acutely aware of things in their environment. Bystanders tend to miss things that others notice easily; they take longer to respond when a lot is happening at the same time; and they may appear more relaxed or have less energy.[82]

It is important to note that when a child presents with the characteristics of a quadrant, it does not imply that they will have functional impairments. There are strengths and weaknesses associated with each pattern of processing.[82] Dysfunction occurs when the pattern persists or negatively affects the child's ability to optimally participate in daily activities.[82] For example, a sensory seeking child may briefly look for additional feedback to complete a task, whereas another seeking child may continuously be on the go and never focus sufficiently. The latter example of sensory seeking is more likely to negatively influence the child's occupational performance in activities of daily living and school, which may result in a diagnosis of sensory modulation disorder.

SMD may result in various functional impairments, including decreased social or play skills; impairments in the ability to adapt sufficiently; impaired self-confidence or self-esteem; difficulty participating in daily activities; or delayed development of fine-, gross-, and sensory-motor skills.[12] Recent studies suggest that children with SMD have functional deficits in various activities of daily living, play, as well as education.[11,128-129] Children with poor SP scores tend to have more motor difficulties, which impedes their performance in the motor aspects of daily tasks.[129] Tactile defensivity may cause sleep disturbances which could, in turn, impede learning and attention. Other studies have confirmed that the level, degree of enjoyment, as well as the frequency of participation, is significantly lower in children with SMD.[11,29,130-131]

2.3.3.5 Assessment of sensory modulation

Occupational therapists rely on a combination of sensory questionnaires and observations to assess sensory modulation.[132] Arousal, attention, emotional reactions and movement are some of the observations which are frequently observed and then recorded on an observation sheet.[67] A recent systematic review carried out by Jorquera-Cabrera et al. (2017), identified 24 measures of sensory processing and modulation in children aged three-to-11 years. The majority of studies used caregiver, parent, or teacher questionnaires.[14] In contrast, clinicians primarily use formal testing or clinical observations to assess SDD and praxis.[14]

The SIPT is considered the “gold standard” of SI assessments. It is a battery of 17 norm-referenced and standardised tests developed by Ayres and published in 1989. The SIPT is a diagnostic and prescriptive assessment tool for children aged four-to-nine years old. It measures tactile processing and discrimination, vestibular and proprioceptive processing, praxis and bilateral integration and sequencing, and perception of shape and space and visuomotor coordination.[120] The specific tests are useful in identifying SDD, praxis and bilateral integration and sequencing disorders.[133] Despite the fact that tactile defensiveness and attention emerged as a pattern of dysfunction in a factor analysis done on the SIPT,[133] the SIPT is not able to identify other types of SMD. Therefore, the SIPT has little value in the assessment of SMD. The SIPT included children with CP in its standardisation; however, it is not recognised as an appropriate tool for children with CP, unless the child is minimally impaired because many items rely on motor function.[67]

The Sensory Processing Measure is a set of rating scales which measure social participation, praxis, and sensory processing difficulties within the home, classroom and school environment, in children aged five-to-twelve years old.[134] The assessment tool supports the identification and treatment of children with SPD. Although it considers sensory modulation, it has more aspects related to praxis.

The Sensory Profile 2 (SP2) is a set of judgement-based caregiver questionnaires comprising of the Infant SP2 (birth-to-six months); Toddler SP2 (seven-to-35months); Child SP2 (three-to-15 years old); and Short SP2 (three-to-15 years old).[82] It is the most recent version of the Sensory Profile, which was also developed by Winnie Dunn.[36] The parents/guardians complete the SP2 questionnaire by indicating the frequency of the child's responses to various sensory experiences using a five-point scale (1= almost always, 2=frequently, 3= half of the time, 4=occasionally, 5= almost never, or 0= does not apply). According to the SP2 manual, does not apply (DNA) should be used sparingly when the question is not relevant to the child, or in cases where the parents/guardians have never observed the behaviour.[82]

The SP2 provides a standardised method in which to evaluate the child's SMP in the context of their home, school and community environments. It includes guidelines for intervention that focus on environmental strategies. Although it refers to "sensory processing", this term refers to the way in which the child is processing different types of sensory information. The test itself, predominantly measures sensory modulation, with very few questions about sensory discrimination. It provides the researcher or clinician with useful information about how the child is processing and modulating information. Information obtained from the SP2 includes:

- **Quadrants (or patterns**) which relate to the four main quadrants, namely, seeking, avoiding, sensitivity and registration;
- **Sensory sections** which relate to the six sensory systems, including the auditory, visual, touch (tactile), movement (vestibular), body position (proprioceptive) and oral sensory sections; and
- **Behavioural sections** which relate to the behavioural patterns associated with sensory processing, that is, conduct, socio-emotional and attentional. Conduct reflects how the child responds to expectations, for example, "rushes". Social-emotional responses reflect the emotional expressiveness of the child, for example, "has strong emotional outbursts". Attentional responses refer to the child's ability to detect critical stimuli, for example, "struggles to pay attention".

The SP2 is simple to use, psychometrically sound, and quick to administer and interpret.[82] The validity and reliability data will be described in the methodology section. There are several disadvantages of the SP2. Firstly, it relies on the parent's/guardian's ability to report on their child's functioning; therefore, it has the potential for responder bias.[34] There may also be discrepancies between the parent's/guardian's responses and the therapist's observations.[34] All questionnaires pose the same disadvantages, and as previously stated, clinicians rely on questionnaires to assess SMD. Secondly, the SP2 has not been validated within the SA population. Furthermore, it has not been translated into any other SA languages. Lastly, despite its ability to detect the presence of modulation difficulties, it is unable to determine the presence of SDD comprehensively.[14] Therefore, it cannot be used to assess SDD. This is a disadvantage within the context of SPD, but not within the context of the study.

The SP2 questionnaires (child and school versions) allow the clinician or researcher to gain insight into the SMD prevalent in the child, as well as which areas may be impacting on functioning at home and school. The limitations of using a questionnaire are well known; however, at present it is the only standardised option of measuring SMD.[34] At the time of this study, Schoen and her colleagues were in the process of developing a reliable and valid scale to measure each of the subtypes of SPD, starting with SMD. The assessment, the Sensory Processing Scales (SPS), will have an examiner-administered portion, as well as an inventory or checklist, which is caregiver or self-rated; therefore, accommodating for both options.[34] This assessment tool is currently undergoing clinical testing and standardisation in the United States of America.

2.3.3.6 Application of the Sensory Profile 2 in diverse populations

The original theory of sensory modulation was developed based on neurotypical children.[2] However, clinicians recognised that some of the symptoms of SMD also occurred in children with different conditions.[21,23-25,28,32-33,79,82] Winnie Dunn and other renowned researchers have contributed valuable knowledge and insight into the concept of sensory modulation, which subsequently led to the development of the SP assessment, as well as the Sensory Processing Framework. This work motivated other researchers to study the application of sensory modulation in various disability groups. There is much speculation about whether sensory modulation disorder is a separate condition or whether it occurs as a comorbid disorder.[17,38] There is a wealth of research indicating that children with neurological and behavioural disabilities have more SMD than TD children. The SP is useful in discriminating between children with and without disabilities,[23] and various studies have used the SP in different diagnostic groups; however, the SP has not been validated on these groups.[23,34]

2.4 SENSORY PROCESSING IN CHILDREN WITH CEREBRAL PALSY

Section 2.2 (containing information about CP) and section 2.3 (containing information about sensory modulation within the SI framework) provide the skeleton and context for the final section, which will review the literature pertaining to sensory processing and sensory modulation in children with CP.

2.4.1 Sensory processing and modulation deficits in children with cerebral palsy

Sensory processing is being recognised as playing a more significant role in motor development and execution than previously anticipated. Information from the sensory systems provides additional information about the movement and the environment, which, in turn, affects the planning and execution of purposeful and precise movements.[50,135] The visual system contributes information about what is in the environment, as well as how objects or people may be moving (exo- or egocentric motion).[135] The auditory system influences the perception of movement by providing information about where objects might be in relation to their sounds.[135] The vestibular-proprioceptive systems directly influence movement by providing a map of where the body is.[135] Somatosensory information also influences motor development. Tactile stimuli provides information about the localisation and characterisation of touch.[50] Tactile and proprioceptive feedback are important for motor planning.[50,60]

In recent years, the influence of sensory deficits on the child's functioning has received more attention. The majority of studies that have been done have concentrated on SDD, including proprioception, tactile discrimination, touch sensitivity, pain pressure thresholds, texture perception, sense of directionality, two-point discrimination, stereognosis, and grip force,[44,50-51,53-64] especially in children with hemiplegia.[44,50,57-

[61,64] There is a significant gap in the literature with regards to vestibular difficulties, as well as SMD in children with CP.[5] The limited research in CP can be attributed to the nature of the condition, whereby there is frank CNS damage. Children with neurological impairments may present with associated SMD; however, these difficulties are likely to be attributed to the CNS damage, rather than to a SPD.[2] Children with CP may have SMD; however, because these difficulties are challenging to assess discretely from the CNS damage, it is difficult for researchers to study them. Another challenge is that the symptoms or behaviours associated with SMD may occur concurrently with the motor symptoms related to CP, which further complicates the assessment. For example, a child with increased muscle tone may be described as passive and withdrawn due their spasticity. However, the very same behaviours may be explained by impaired sensory modulation. The child could have poor registration, which may be contributing to the passive and withdrawn behavioural response. Therefore, knowledge of both the motor and sensory aspects is crucial for accurate assessment and intervention.

Despite the limited research, as well as the unavailability of a validated assessment tool, children with CP have been found to present with significant SMD.[37,68-71,79] Furthermore, SMD are often treated using SI or sensory-based strategies, in conjunction with other strategies, such as neurodevelopmental therapy. Only one study has been done using an SI approach in the CP population. The study reported significant changes in sitting and crawling in children with CP after SI intervention.[73] SI intervention can also improve the level of arousal, and subsequently, the muscle tone, attention, motivation, postural control, and motor planning skills in children with CP.[5] Interestingly, researchers have found that the structural connectivity of the corticospinal and thalamocortical tracts have the potential to improve or be restored in children with CP after therapeutic intervention.[52,136] These findings provide substantial evidence that sensory-based interventions may improve the abnormal somatosensory cortical responses. Therefore, further research into sensory-based interventions in children with CP is necessary.

Both the primary and the secondary impairments can cause sensory processing and modulation deficits. Primary impairments occur as a result of damage to the cortical and subcortical areas of the brain, including the somatosensory areas.[51,62] Primary motor impairments, such as limitations in movement, abnormal and compensatory movement patterns, as well as insufficient postural adjustments, affect the type, quantity and quality of tactile-proprioceptive-vestibular sensory experiences.[67,74] Children with CP are less able to move and explore their environments and experience different sensations of movement. These motor difficulties subsequently impact on the child's body scheme, postural control, motor planning, bilateral coordination, and cognitive development, resulting in secondary impairments and abnormal sensory-motor feedback.[62,74] Studies have shown that the impaired sensory feedback impedes the child's ability to make initial or anticipatory adjustments in their motor plan.[52] Therefore, the sensory impairments can also contribute to or exacerbate the motor impairments.

The type of play occupations that children with CP engage in further limits their ability to adequately process and integrate sensory information, often resulting in modulation impairments.[74] Furthermore, sensory modulation and registration impairments can directly influence posture and movement patterns.[135] A child with SUR may present with decreased movement, and a child with SOR may present with excessive or disorganised behaviour;[135] therefore, it is imperative that clinicians consider both the sensory and motor contributions, to understand the child's behaviour.

Some researchers have proposed that different subtypes of CP present with specific sensory modulation impairments.[5,135] Children with ataxia are likely to have vestibular-proprioceptive processing disorders, which could be associated with damage to the cerebellum.[137] Children with dyskinesia may have poor feedback and feedforward, as well as vestibular-proprioceptive registration disorders and tactile processing difficulties, associated with the lesions in the thalamus and basal ganglia.[138] Spasticity, occurring as a result of damage to the cerebral cortex or pyramidal tracts,[49] may result in motor planning disorders in children with hemiplegia; sensory registration or modulation disorders in children with spastic quadriplegia; and gravitational insecurity and/or under-responsivity to proprioceptive and vestibular stimuli in children with spastic diplegia.[5,135] Studies using somatosensory evoked potentials have found differences in responses to somatosensory stimulation between the various subtypes of CP; thereby, supporting the view that different sensorimotor systems are involved in different types of CP.[51,53,139]

Recent advances in technology have allowed researchers to gain further insight into the role of the sensory pathways in motor functioning. Neuroimaging studies using various modalities including diffuse tensor imaging, magnetoencephalography, and resting-state fMRI have reported that both the motor and the sensory pathways contribute to the clinical picture in CP. Children with spastic CP have been found to have altered or reduced somatosensory processing in some areas of the cortex.[50-51,140] Other studies reported disturbances in the white matter tracts connecting to the cortex, which contribute to the motor weakness observed in children with CP.[46-50,141] In some cases, such as in prematurity, the white matter fibres may be more affected than the motor ones.[46-47,65] These studies have provided critical evidence that the clinical picture of CP may not only be related to the disruptions in the motor pathways, but also to the disruptions in the sensory pathways. Evidence has now emerged that the somatosensory cortices desynchronise in response to sensory feedback, which is in contrast to the clearly synchronised cortices of TD children.[52] Motor errors were observed to be the most obvious when there was less synchronisation in the somatosensory cortex. Since the somatosensory cortex is responsible for providing feedback to the motor system, there seems to be an association between the responsiveness of the somatosensory cortex to afferent feedback, and the motor difficulties seen in children with CP.

Several sensory pathways between the cortex, brainstem, cerebellum, basal ganglia, spinal tracts and pyramidal tracts have been linked to the planning and execution of movement.[49] The thalamus acts a relay station for incoming sensory information from the peripheral nervous system. It then communicates with the parietal and occipital regions of the cortex through the posterior thalamic tracts.[47] The parietal cortex connects to the premotor and prefrontal areas, as well as to the cerebellum. After sensory integration occurs in the basal ganglia, the peri-rolandic motor centres determine the motor output and transmit the information down the corticospinal tracts.[47] Damage to sensory pathways, such as impaired posterior thalamocortical pathways in white matter injuries and prematurity, may alter the sensorimotor connections, further weakening motor outputs.[47]

2.4.2 Assessment of sensory modulation disorders in children with cerebral palsy

Several studies have examined SMD in children with CP using various versions of the SP. The first researchers to do so were Prakash and Vaishampayan (2007), who compared the sensory processing abilities of children with CP (n=30) to TD children (n=30), aged five-to-eight years old using the SP. Their study included all the subtypes of CP (83.3% spastic, 3.3% hypotonic, 10% ataxic, and 3,3% dyskinetic). Forty of the 125 items (32%), and seven of the 14 components (50%) of the SP were significantly different ($p<0.05$) between the two groups. Children with CP deviated from the TD group in the modulation of body position and movement, auditory, vestibular and multisensory processing sections, suggesting that these may be problem areas in the CP population.[37]

In an attempt to identify whether differences occurred between the spastic CP subtypes, Soomro et al. (2011) used the SSP on children with hemiplegia (n=13), diplegia (n=23) and quadriplegia (n=24), aged four-to-eight years old. Significant differences ($p<0.05$) occurred in eight of the 38 items (21%). Their findings suggested that the diplegic and quadriplegic subtypes presented with more severe sensory processing difficulties than the hemiplegic group. Movement sensitivity and sensory seeking behaviours were found to be more prominent in children with diplegia and quadriplegia. Furthermore, children with quadriplegia were also reported to have more auditory processing impairments. The findings confirmed the presence of tactile processing difficulties among children with CP, although there were no differences identified between the subtypes.[68]

Gupta (2013) also used the SSP; however, she compared the sensory patterns between TD children and various disability groups, aged three-to-12 years old. The disability groups included children with CP who had been identified with sensory issues (CPSI) and without sensory issues (CPNO). This study also confirmed that children with CP had more SMD than TD children. Additionally, the CPSI group had more difficulties than the CPNO group.[79]

Pavao and Rocha (2017) replicated the study done by Prakash and Vaishampayan (2007) using a larger sample size. When they compared the SP scores of children with spastic CP (n=43) to TD (n=59) children, aged three-to-15 years old, they found significant differences ($p<0.002$) in sixteen of the 23 (69%) categories. Due to the small sample size in their study, as well as the unequal distribution between the GMFCS levels, they were unable to identify any differences between the GMFCS levels.[69]

Having confirmed that prevalence of SMD in children with CP, researchers are now trying to examine the subtypes and GMFCS levels more closely. Kim (2015) used the SSP to compare children with (n=40) and without (n=40) spastic diplegia. Significant differences were reported in the total scores, as well as in six of the seven sections. The low energy/weak and the movement sensitivity sections emerged as the most predominant difficulties in the spastic diplegia subtype. Additionally, preschool children (three-to-six years old) were found to have more difficulties than the school children (seven-to-nine years old), suggesting that SMD becomes less prevalent with age.[70]

The most recent study conducted by Park (2017) compared the sensory processing, fine motor (using MACS), and gross motor (using GMFCS) abilities of 104 children with CP, aged seven-to-ten years old. This study found that SMD were more severe in the higher GMFCS and MACS levels, especially in the tactile sensitivity, movement sensitivity, auditory filtering and low energy/weak sections.[71] For the first time, a relationship between GMFCS level and SMD was identified.

All the studies found the SP and SSP to be a valuable tool in assessing SMD in children with CP. These studies provided important evidence that children with CP process and respond to sensory information differently to TD children. The latest study indicated that sensory difficulties increase as the level of GMFCS and MACS increases.[71] Only one study examined differences between the subtypes;[68] however, this study focused on the spastic subtype and not the other subtypes of CP. Small sample sizes were common limiting factors in these studies. No studies done thus far, have confirmed the presence of different SMP and SMD in the different subtypes of CP, as proposed by Blanche and Nakasuji (2001).

2.5 SUMMARY OF LITERATURE REVIEW

Chapter two provided a non-exhaustive summary of the available literature pertinent to the study. Sensory modulation disorders are a complex group of disorders which fall under the umbrella of SPD. Modulation, one component of SPD, is commonly assessed using the SP. The SP is a useful tool to identify SMD in neurodevelopmental disorders, including CP. There is growing evidence that children with CP present with SMD, although the focus of assessment and therapy continues to be on the motor impairments. No study has examined and compared the SMP in all the CP subtypes, and therefore it is still unclear as to whether different patterns occur in the different subtypes. Chapter three will examine the methodological procedures used in the study.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 INTRODUCTION

The main purpose of this chapter is to discuss the methodology utilised in this study. Section 3.2 deals with the methodology, including the design, sample, population, as well as the setting. Section 3.3 will offer a comprehensive analysis of the SP, including the use, scoring and interpretation. Thereafter, the researcher describes the data collection procedure (section 3.4) and management of the data (section 3.5). Lastly, section 3.6 outlines the ethical considerations in the study.

3.2 METHODOLOGY

3.2.1 Design

The researcher used a quantitative, non-experimental, comparative-descriptive design. Quantitative studies are based on measurable aspects of human behaviour and are either experimental or non-experimental.[142] The researcher aimed to compare the sensory modulation patterns in the different types of CP by obtaining data from SP2 (Appendix A), which includes the SP2 quadrant calculation sheet (Appendix B) and SP2 summary score sheet (Appendix C). Therefore, the data was quantitative. Non-experimental designs do not manipulate the independent variable through intervention, but rather observe the behaviour and examine the possible relationships between variables.[142] The focus of the study was on assessment, and no experimentation or treatment was involved; therefore, a non-experimental design method was selected. These designs can be descriptive or correlational. Descriptive designs merely describe the behaviour; whereas comparative-descriptive designs describe the variables, and examine whether differences occur between two or more groups.[142] The study aimed to describe and compare the differences between the different subtypes of CP by means of descriptive statistics. The researcher also examined the relationship between the independent variable (CP) and the dependent variables (quadrants, sensory systems, and behaviours) through inferential statistics. Therefore, the study was both comparative and descriptive in nature.

In summary, the design was a quantitative, non-experimental, comparative-descriptive design. This method was based on the aim of the study, as well as on the literature reviewed. Similar designs have been used to describe sensory modulation and processing disorders in other conditions, including CP.[33,37]

3.2.2 Sample

3.2.2.1 Study population

Since the study focused on children with CP, the population consisted of all the learners who had received a diagnosis of CP and who were attending LSEN schools in Johannesburg, as well as their parents/guardians. The parents/guardians were directly involved in the study, as they were required to complete the SP2 questionnaire; whereas the learners were indirectly involved, as the information obtained in the SP2 was only related to them. A sample was derived from the population, based on the various inclusion and exclusion criteria, which is discussed below in 3.2.2.4.

3.2.2.2 Study setting

From the greater population of children with CP, a specific study setting was identified. The researcher is employed at an LSEN school in Johannesburg, and therefore decided to focus on children who attended similar schools. Due to time and financial constraints, the researcher chose to concentrate on one area in Gauteng, namely, Johannesburg, rather than including the entire province, or country. A list of schools from the Gauteng Department of Education (GDE) and schools that met the inclusion criteria were given an opportunity to participate in the study.

Both mainstream and LSEN schools follow the curriculum assessment policy statements, which is also known as the CAPS curriculum. In Gauteng, LSEN schools are classified in terms of the types of children that they cater for. Children are assessed and placed into an appropriate LSEN school based on their scholastic limitations. The main categories of schools are:

- **Specific learning disabilities (SLD):** These are schools which cater for children which difficulties in reading, writing, mathematics, or dyslexia.

- **Intellectual disabilities:** There are two categories of schools for children with intellectual disabilities, that is, mild intellectual disabilities (MID) and severe intellectual disabilities (SID). There are no specific schools for moderate intellectual disabilities (MOID), or profound intellectual disabilities (PID). Children with MOID are usually placed in MID or SID schools. Children with PID are usually placed in stimulation centres.
- **Physical disabilities:** These are schools which cater for children with various physical disabilities including, CP, traumatic brain injuries and muscular dystrophy.

3.2.2.3 Sampling procedure

The researcher used non-probability sampling to select the schools and participants. A combination of convenience and judgement sampling was used to select the schools. Convenience sampling is based on the availability of the sample.[142] The researcher needed to travel to the schools to obtain consent, to explain the study and to deliver and collect the research documents. This incurred travelling and time costs, and therefore schools were selected based on their proximity to the researcher. The school-based therapists were required to assist in the research. The willingness of the school-based therapists to participate in the data collection phase was critical to the study; therefore, this was also considered when selecting the schools. Judgement or purposive sampling relies on the researcher's judgement.[142] The researcher used clear, pre-determined criteria to guide the selection of suitable schools. The school's suitability for the study was considered based on the inclusion criteria outlined in 3.2.2.4. From the list of schools obtained from the GDE, six potential schools were identified. Of the six schools contacted, five chose to participate.

Once the school had been selected, permission was obtained by the principal, school governing body (SGB) and school-based therapist, as per the requirements of the GDE. The researcher then asked the therapist to provide a list of the learners who met the criteria for the study. Due to the limited number of schools and the limited number of learners in the schools, all the learners who met the inclusion criteria were selected to participate study in order to meet the required sample size. Therefore, a combination of convenience and purposive sampling was also used to select the participants.

The researcher was aware that this form of sampling would have negative implications with regards to being representative of the entire population; however, similar studies in the literature also used this sampling method.[33,68]

3.2.2.4 Selection criteria

The selection of participants occurred in three phases. The first phase involved selecting the schools from which the sample would be drawn, as described above. The second phase involved selecting the participants from the identified schools. The last phase was an exclusionary phase, whereby exclusions were made based on whether the participants or parents/guardians met the inclusion/exclusion criteria, using information obtained from the parent questionnaire or the telephonic conversation.

<u>Selection criteria for the schools:</u>

In order for a school to be selected the school had to:

- Be located in Johannesburg (North, East, West), in Gauteng.
- Be a registered LSEN school for children with physical (CP) and learning disabilities; specifically, MID to MOID, and/or SLD.
- Follow a CAPS or adapted CAPS curriculum.
- Be an English medium school, whereby, the learning and communication with the learners and parents/guardians occurs in English. Some schools were dual-medium (English and Afrikaans) and they were also included.
- Have written permission from the principal (Appendix D).
- Have written permission from the SGB (Appendix E).
- Have written permission from the school-based therapist(s) (Appendix F).

<u>Inclusion criteria for the learners:</u>

In order to be included the learner had to be:

- Attending one of the participating LSEN schools in Johannesburg.
- Diagnosed with CP before the age of 2 years old.
- Classified as functioning on a GMFCS level I, II or III.
- Aged between 5 years 0 months to 14 years 11 years old.
- Receiving occupational therapy intervention at school.

- Of normal intellect, or be classified/diagnosed as having SLD, MID, or MOID. Not all learners had received an assessment by an educational psychologist, or the assessment was outdated. Moreover, is often difficult to obtain an accurate intellectual quotient (IQ) score in a child with CP due to their physical limitations. LSEN schools in Johannesburg often classify children as "educable", "trainable" or "stimulable" in order to place them. If no IQ score was available, learners who were classified as "educable" and who were following a CAPS or adapted CAPS curriculum at school were eligible for inclusion.

<u>Exclusion criteria for the learners:</u>

Learners were excluded based on the following criteria:

- Learners with SID or PID were excluded, as research indicates that they have more severe SPD.[31] Learners who were unable to follow a CAPS or an adapted CAPS curriculum, were excluded. Although these learners should have been excluded automatically based on the criteria for school selection, some schools may still have had learners placed in their school with SID or PID.
- Learners classified as functioning on a GMFCS levels IV or V were excluded, as some of the questions in the SP2 pertain specifically to ambulatory children, especially within the movement and body position processing sections. The movement and body position sections relate to vestibular-proprioceptive processing. Although all children with CP present with some form of physical impairment, GMFCS levels I-III are less severe and all these children walk to some degree, with or without an assistive device. The researcher assumed that children functioning on level IV and V would have different sensory processing and modulation patterns in comparison to children functioning on level I-III.
- Learners diagnosed with a postnatally acquired CP or paediatric brain injury after the age of 2 years old were excluded from the study, as the definition of CP used in the study, refers to damage to the foetal or developing brain.[85] The upper age limit was set at two years old for this study based on the literature reviewed.[76,94]
- Learners were not excluded if they presented with associated impairments as these were considered to be part of the CP clinical picture, as highlighted in the definition. However, children with severe or uncontrolled epilepsy were excluded, as this may cause further brain impairments.[89] Children with severe hearing or

visual impairments that were not being accommodated for with assistive devices, such as hearing aids or glasses, were also excluded. The researcher anticipated that these impairments might have affected the auditory and visual sections of the SP2.

- Learners who had been formally diagnosed with a comorbid disorder, i.e. autism, ADHD or any genetic syndrome were excluded, as research indicates that these conditions already present with SMD.[21,23,28,127] This exclusion was not solely based on their medication alone, as many children with CP present with attention difficulties, and are then treated with methylphenidate (Ritalin). The decision to exclude them was based on a formal diagnosis in their file by a medical professional.

Inclusion criteria for the parents/guardians of the learners:

In order to be included parents/guardians had to:

- Be the parent/guardian of a learner attending an LSEN school in Johannesburg which met the inclusion criteria.
- Be literate and understand English. A high school education level (Grade 8) was considered to be an acceptable level of English language.

Exclusion criteria for the parents/guardians of the learners:

Parents/guardians were excluded based on the following criteria:

- Incomplete informed consent forms (Appendix G).
- Incomplete parent background questionnaire (Appendix H).
- Incomplete Sensory Profile 2 questionnaire (Appendix A).
- The following procedure was followed to exclude parents/guardians based on their understanding of the English language:
    - The researcher gave each participant an opportunity during a telephonic conversation to indicate whether they understood the questions. If they reported that they did not understand the questions or the study, they were excluded.
    - If the researcher felt as though the parent/guardian did not sufficiently understand the questionnaire during the telephonic conversation, they were

excluded. For example, leaving out more than one section or several questions from each section due to lack of understanding.

3.2.2.5 Sample size

The sample sizes used in other studies was found to be insufficient, and therefore the biostatistician recommended a sample size of 150 participants (Appendix I). This sample size was based on the number of potential participants in the schools who had agreed to participate in the study. All of the learners (n=217) in the schools who were eligible candidates (based on the criteria) were initially included in the study. The 217 potential candidates received the informed consent forms and SP2 questionnaire. A larger number of participants were included as the researcher anticipated that some participants might not return the forms. A total of 164 participants returned the forms.

Ten participants were then excluded from the study (four had an incorrect diagnosis provided by therapists; three had incomplete forms due to lack of understanding; two chose to withdraw when contacted telephonically; one was excluded based on the incorrect age). Therefore, the final sample size was 154.

3.2.2.6 Timeframe

Sample selection and data collection occurred concurrently from August 2017 to the end of September 2017.

3.3 MEASUREMENT INSTRUMENTS

3.3.1 Background parent questionnaire (Appendix H)

The researcher devised a two-page background questionnaire for the parents/guardians to complete. The questionnaire included:

- **Relevant demographic information:** Demographic information, for example, name, age, gender, and home language was included for primarily analytical purposes. As per the recommendation from the Faculty of Health Sciences Research Ethics Committee, the race was excluded. The child's race was not anticipated to have any bearing on the data. The questionnaire included the child's name so that this could be included in the summary report, which was given to each parent/guardian at the end of the study. All the documents, including the report were sealed in envelopes, thereby ensuring confidentiality.

- **Parents'/guardians' highest level of education (HLOE):** The researcher enquired about the parents'/guardians' HLOE to assist in determining whether they would have sufficient educational background to understand the questionnaire.
- **Prenatal, perinatal and postnatal history:** Information regarding the pregnancy and birth history was asked to determine the influence of these factors on sensory modulation.
- **Medical information:** Information including associated impairments, medication, therapy received were included to assist with the exclusion of children with severe difficulties or comorbid disorders.

The questionnaire was not standardised, and no validity or reliability testing was done. The primary aim was to obtain additional information on the participants. The questionnaire was devised in such a way that the parents/guardians could complete it quickly. The questions were mainly in a checklist format, whereby the parents/guardians selected the appropriate response(s). There were a few items which required them to provide a short response.

3.3.2 Sensory Profile 2 (Appendix A)

3.3.2.1 Selection and suitability of the Sensory Profile 2

At the time of the study, the SP was the only standardised and comprehensive assessment tool available to assess sensory modulation. An advantage of the SP is that the questionnaire is completed by the parent/guardian, and the therapist does not need to be present. The researcher chose to use the child version of the SP2 based on the age band of learners in the schools. Although other studies used the first version of the SP or the SSP,[37,68-69,79] the researcher chose to use the SP2 as it is the most recent version of the SP. The second version has fewer questions than the SP (86 versus 125); therefore, it is quicker to complete. Furthermore, there are no double negatives in the SP2, making it easier to read than the SP.[82]

The SP2 has not been standardised on the SA population or in other SA languages. There are 11 official languages in SA. In order to control this variable, the researcher stated that the parents/guardians needed to be able to read and understand English in the inclusion criteria. Since there are so many official languages spoken in Johannesburg, and many South African people speak more than one language, it would have been difficult to standardise the test in all of the official languages. Furthermore, although many South Africans converse in their home language, they are not necessarily able to read in that language. Therefore, the original questionnaire was used.

3.3.2.2 Reliability and validity

The SP2 was standardised on 1791 English children in the United States of America. The infant (n=68), toddler (n=347), child (n=697) and school companion (n=679) versions were used in the standardisation, with 337 children rated on both the child and school companion SP2. Approximately 10% of the population presented with various disabilities, including ADHD, ASD, LD, language disorders, and ID.[82]

The internal consistency for each quadrant, sensory section, and behavioural section was calculated using Cronbach's alpha. The alpha values were mostly in the adequate (>0.70) to excellent range (>0.90), with only the visual section (0.60) scoring below 0.70. The test-retest reliability was calculated using the intra-class correlation coefficients. The test-retest reliability coefficients for the SP2 ranged from 0.87-0.97, reflecting good to excellent reliability. The intra-class correlation coefficient was evaluated based on the first and second test administrations to determine the interrater reliability. The interrater reliability coefficients ranged from 0.49-0.89, with most falling in the acceptable to good range. The visual (0.49) and touch (0.55) processing sections had lower coefficients. The validity between the SP and SP2 revealed generally moderate to high validity correlations, suggesting that the integrity of the first version was maintained.[82] A recent validity and reliability study reported a good fit with the four-factor model (based on Dunn's Sensory Processing Framework).[143]

3.3.2.3 Scoring of the Sensory Profile 2

The SP2 is comprised of 86 questions and nine sections. Question 1-8 are from the auditory section, 9-15 are from the visual section, 16-26 are from the touch section, 27-34 are from the movement section, 35-42 are from the body position section, 43-52 are from the oral sensory section, 53-61 are from the conduct section, 62-75 are from the social-emotional section, and 76-86 are from the attentional section. The four sensory quadrants (seeking, avoiding, sensitivity, and registration) are derived from these questions. Therefore, the sections have questions pertaining to different sensory quadrants. Each question receives a score of between one (almost never) and five (almost always). Questions that are not relevant to the child are scored as “does not apply” and receive a score of zero.

The SP2 reflects three main sets of results:

1. Quadrants, i.e. seeking, avoiding, sensitivity and registration.
2. Sensory sections, i.e. auditory, visual, tactile, movement, body position, and oral sensory.
3. Behavioural sections, i.e. conduct, social-emotional, and attentional.

The total raw scores for the sensory and behavioural sections are calculated on the SP2 (Appendix A). The section raw scores are calculated based on the sum of the questions in the section. The quadrant raw scores are based on the sum of the relevant questions in the quadrant. The quadrant raw scores are calculated on the quadrant grid (Appendix B). The total raw scores for the quadrants, sensory sections, and behavioural sections are then recorded on the SP2 summary score sheet (Appendix C). The raw score is then converted into the cut scores. The cut scores are based on the bell curve continuum, reflecting the mean and Sd of the normative data.[82] Therefore, the child’s responses are compared to the collective responses of other children. The cut scores are classified as Much Less” (-2Sd), “Less Than (-1Sd), “Just Like”, “More Than” (+1Sd), and “Much More” (+2Sd).[82] These cut scores will be referred to as bands in the results and discussion section.

3.4 PROCEDURE

3.4.1 Pilot study

The SP2 and the parent background questionnaire are in English. Although the parents/guardians were required to understand English, the researcher was aware that English might not have been their home language. A pilot study was conducted prior to the main study to determine whether the questions were phrased in a manner that the parents/guardians would understand. The pilot study involved 30 participants, as recommended by the biostatistician.

No changes were made to the data collection procedure described in 3.4.2, and based on this, the results from the pilot study were included in the results and data analysis.

3.4.2 Main study

The study involved three main phases. The study ran concurrently at all the schools from August 2017 until the end of September 2017.

Phase 1: Candidate selection

The potential candidates were selected based on the inclusion criteria outlined in 3.2.2.4. The school-based occupational therapist(s) were asked to select the learners who met the criteria from their school, as they knew the learners and had access to their files. The selection procedure was explained to the school-based therapist(s) both verbally and via email. The procedure was also available in their copy of the consent form (Appendix F). The SCPE classification and GMFCS levels were known to all the therapists and copies of this were also provided to them. The researcher was also available to assist with the selection process. The researcher was responsible for the data collection at one of the five schools. The participants were identified from the official school class lists, ensuring that all the participants had a fair chance of being selected. Each candidate received a research number.

The school-based therapists were also responsible for classifying the participants into the different subtypes of CP using the SCPE flow diagram,[99] and GMFCS levels.[95] Any medical information available in the learner's file was used to assist with the classification, as well as inclusion and exclusion of the learners. The lists of eligible candidates were tabulated and emailed to the researcher (Appendix J).

It should be noted that the researcher chose to adapt the SCPE classification to include only the spastic, dyskinetic and ataxic subtypes. The sub-classifications of the

SCPE, that is, the choreoathetotic and dystonic CP subtypes, and spastic bilateral and spastic unilateral CP subtypes were not used. The school-based therapists were made aware of this. Since there are fewer dyskinetics in the population, the researcher decided to keep the dyskinetic subtype as one group, rather than have two smaller groups of choreoathetotic and dystonic CP. This increased the statistical power and validity of the data for the dyskinetic group. Furthermore, these two subtypes are difficult to distinguish and often occur together,[100-101] which may have resulted in errors in the classification.

The researcher also decided to adopt the more commonly known spastic diplegic, spastic hemiplegic, and spastic quadriplegic subtypes, rather than use the bilateral and unilateral spastic CP subtypes in the SCPE classification model. The study aimed to identify the differences between the subtypes, and the SCPE classifies the diplegic and quadriplegic subtypes together. From a sensory modulation perspective, these subtypes may have very different SMP. It would have been time-consuming to add the MACS to the data collection and analysis procedure to distinguish between the two subtypes. Should the data obtained in the study be needed for CP registers, it would still be possible to classify them into the SCPE classification.

Phase 2: Sending out research information (August- September 2017)

Phase two was concerned with sending out all the relevant information to the parents/guardians of the potential participants identified in phase one. There were two packs of information. The first pack included the informed consent forms (Appendix G), parent background questionnaire (Appendix H), and a leaflet explaining sensory modulation (Appendix K). The second pack included the SP2 questionnaire (Appendix A), a leaflet explaining sensory modulation (Appendix K), a form explaining how to complete the questionnaire (Appendix L), and a consent form to give permission for a copy of the report to be given to the treating therapist at the school (Appendix M). The completion of the SP2 in this manner, whereby the therapist is not present during the completion of the questionnaire, is an accepted form of administering the SP2.[82]

The research information was sent home with the participants in an unsealed envelope in their message books. The front cover of the envelope provided a short description of the study, the researcher’s contact details, and a return date. The research number was marked in the corner. The back of the envelope included a summary checklist to encourage the parents/guardians to complete all the aspects of the study before returning the envelope. The parents/guardians were informed that they needed to seal the envelope before returning the envelope to the school.

An SMS was sent on the date that the parents/guardians received the pack to inform them of the study. They were made aware that they could contact the researcher at any time during the study. The researcher's contact details were available on the cover letter of the research pack, on the informed consent form, as well as in the SMS. The parents/guardians were given two weeks to return the forms. Once they were satisfied with their responses, they were then required to return the forms to the school in the sealed envelope on the specified date. A reminder SMS was sent a few days before the return date. The parents/guardians were given an additional two weeks to return the forms to account for any delays in receiving or returning the forms, or for those that had forgotten to return the forms, but still wished to participate in the study. For example, in some cases, the learners were in a hostel and would only go home on the weekends. The researcher attempted to keep in regular contact with the parents/guardians through SMS reminders and telephonic conversations, without being invasive or persuasive. This method assisted in securing a high compliance rate of 75.58%.

Phase 3 Contacting the parent/guardians

Phase three included contacting the parents/guardians telephonically to:

- Explain the study and ensure that they had understood the consent form.
- Provide an opportunity for parents/guardians to ask questions about the study.
- Clarify and/or complete questions which they had left out.
- Clarify cases where 2-3 or more questions in a section were marked DNA.
- Ensure that they were satisfied with their responses. Some parents/guardians requested to re-complete their questionnaires, and those questionnaires were sent back.
- Obtain verbal consent, whereby the parent/guardian had forgotten to sign one of the consent form(s) but had completed all the other necessary documents. In the

case were verbal consent was obtained, the informed consent form was read to the parent to ensure that they were aware of their rights to withdraw from the study.

The researcher attempted to contact the parents/guardians before they returned the forms to the school. However, this was not always feasible, as there were delays in contacting the parents/guardians due to having incorrect contact details, or the parents/guardians not responding to calls. All the parents/guardians were contacted within one-to-two weeks of the researcher collecting the forms.

3.4.3 Variables and control measures

The independent variable in the study were the different subtypes of CP, i.e. ataxic, dyskinetic, and spastic CP. The dependent variables were the quadrants, the sensory sections, and the behavioural sections. Other dependent variables relevant to this study were GMFCS levels, age, gender and birth history.

3.4.3.1 Variables pertaining to participants

The following participant variables were considered and controlled as much as possible by the researcher:

- **Age:** All the ages of the child SP2 were included, except the three-to-four-year old age band as these children were not in the sample setting. The standardisation studies done on the SP2 found the difference between the raw scores of younger children (three-to-eight years old) and older children (nine-to-14 years old) to be clinically insignificant;[82] therefore, it was assumed that age would not impact on the results.
- **Gender:** Both males and females were included in the study. The differences between the males and females in the normative data were also found to be clinically insignificant.[82]
- **Intellectual functioning:** Different levels of intellectual functioning might have influenced the results. Therefore, this study chose to include only the learners who were considered to be educable, that is, learners with normal intellect, specific learning disabilities, or mild to moderate intellectual disabilities. All the schools selected for the study had the same admission policies with regards to the learners they admitted.

- **Gross motor functioning:** The researcher assumed that children who walk (GMFCS levels I-III) would have different sensory experiences to those who do not walk (GMFCS levels IV-V), especially in the somatosensory and vestibular systems. Therefore, the researcher only selected children who were classified as functioning on GMFCS levels I-III (walkers).
- **Associated impairments:** The different impairments associated with CP, such as epilepsy and visual impairments may have impacted on the findings. The researcher attempted to control these factors by excluding learners with severe impairments.
- **SES:** The researcher chose to include children from a similar SES background. The majority of the learners in the schools were from the low to middle-income status groups.
- **Prior intervention:** Previous occupational therapy intervention may influence sensory modulation patterns. To control for this variable, all children had to be receiving occupational therapy intervention at school. Similar studies using the SP included children receiving intervention.[33 69] The study focused on the assessment of SMD, rather than on the treatment. Therefore, the study was not measuring change after intervention. A person's "sensory profile" is thought to remain relatively stable over time, and therefore the researcher assumed that the SP2 would still be able to detect SMD in children receiving intervention.

3.4.3.2 Variables pertaining to the researcher and/or assessment tool

The following was done by the researcher to ensure quality and accuracy of the data:

- The inclusion and exclusion criteria of learners and parents/guardians were strictly adhered to.
- The GMFCS and SCPE are internationally accepted and recognised methods of classifying children with CP. The classification was done by trained occupational therapists using the SCPE and GMFCS guidelines to allow for consistent classification of the learners.
- The SP2 is a standardised and well-recognised occupational therapy assessment tool. The tool has good instrument validity and reliability, and it has been used in similar studies.[37,68-69,79] The test administration and scoring procedures outlined in the SP2 were followed.

- The researcher attached an explanation of sensory modulation (Appendix K), as well as how to complete the questionnaire (Appendix L) to assist the parents/guardians understand how to complete SP2.
- The researcher ensured that sufficient time was allocated to complete the questionnaire and that each participant had the opportunity to ask questions during the telephonic conversation. Where relevant, questions were clarified to ensure that the participant understood the questions sufficiently. To avoid bias, and jeopardising the results, the researcher ensured that the telephonic conversations were conducted in a similar manner as outlined in 3.4.2. Questions asked by the parents/guardians were answered in a non-biased and non-suggestive manner as suggested in the SP2.[82] Standard, or similar responses and examples were given to all parents/guardians.
- The researcher provided each parent/guardian with an opportunity to complete all uncompleted questions. If a response was changed or added, this was done with permission. The scores were marked in a different colour to highlight the changed response. The SP2 manual does make allowances for clarifying responses, especially in the case where questions are left out or where DNA is used too frequently.[82]
- In the case where the researcher suspected that the parent/guardian had misunderstood the DNA option, the researcher provided clarity by explaining the use DNA in a consistent manner. This was also described in the leaflet on how to complete the SP2. Clarification was provided when one of the following was observed:
    - The participant marked 2-3 items or more within the section as DNA and/or,
    - The participant marked DNA in several sections.
- According to the manual, higher or lower scores which fall outside of the norm should be interpreted carefully, using sensory integration knowledge.[82] All scoring and analysis were done by the researcher, who is qualified to score and analyse the results of the SP2.
- To avoid having to input large amounts of data, which would pose a greater risk of human error, the researcher captured the raw score data into the Excel spreadsheet throughout the data collection phase. A formula was used to calculate the total raw scores and SP2 bands, in order to diminish the risk of human errors

being made. Incorrect scores of above five or zero scores were automatically highlighted so that they could be verified and/or changed. Impossibly high or low total raw score were also flagged for the researcher to check. Once all data was recorded, it was checked twice by the researcher.

3.5 DATA MANAGEMENT AND ANALYSIS

3.5.1 Data recording

All data was captured on a Microsoft Excel spreadsheet. Each row reflected the 154 participants, labelled no.1-217 (the participant research numbers). The columns included all the relevant demographic information (birth, medical, and educational history) which was obtained from the background questionnaire, as well as all the SP2 variables.

The raw scores were manually captured into the spreadsheet to create a general data structure. The spreadsheet formulas were used to automatically add up the total raw scores for the quadrants, sensory sections, and behavioural sections. The excel program also automatically converted the raw scores into the five bands. These bands were colour coded for visualisation purposes. The structure of this spreadsheet allowed for easy comparison between the different variables, such as the CP subtype, GMFCS levels, gender and age.

The researcher compiled a standard report template in Excel (Appendix N). The program was written so that the participant's results could be copied into the report, and the excel spreadsheet would then automatically fill in the explanation of the score, as well as suggestions for how to manage the behaviour at home and school. This was then copied and formatted into a Word document.

3.5.2 Data analysis

The data analysis was done with the assistance and guidance of a biostatistician from the University of Pretoria. Both nominal and ordinal data were analysed. Nominal data included the subtypes, GMFCS levels, age, gender, gestation and birth weight. The ordinal data was obtained from the SP2 (Likert ranked 1-5).

The SP2 raw scores are compared to the bell curve, which is the collective responses of peers in the same age group.[82] Scores between -1Sd and +1Sd, that is, in the "Just Like" band, represent approximately 68% of the population. Scores between 1Sd and 2Sd on either end of the curve, represent 28% of the population, with 14% in the "More Than", and 14% in the "Less Than" band. Scores more than 2Sd from the mean on either end of the curve, represent 4% of the population, with 2% in the "Much More", and 2% in the "Much Less" band.[82]

For the purposes of this study, the "More Than" and "Much More" bands were combined (defined as "More"), and the "Much Less" and "Less Than" bands were combined (defined as "Less"). "More" and "Less" are also described in the SP2 manual. Those falling in the "More" and "Less" bands were considered to have sensory modulation difficulties. When 50% or more of a subtype or group scored outside of the norm, that is, in the "More" or "Less" bands, they were said to present with sensory modulation difficulties.

5.5.2.1 Other factors

The main objectives of the study were to describe and compare the SMP in the CP subtypes. The three factors being examined under the construct of sensory modulation were the quadrants (patterns), sensory systems, and behavioural responses. However, the quadrants consist of the neurological thresholds (high and low) and self-regulatory strategies (passive and active), as outlined in Dunn's Sensory Processing Framework. Therefore, the researcher chose to examine the factors within this model more closely within the CP sample, as well as in the different subtypes.

The quadrants, sensory systems, and behavioural responses are based on the scores of the individual questions. Due to the nature of the SP2 scoring, a section may score typically, even though several questions are highlighted as problematic by the parent/guardian. For this reason, the researcher chose to scrutinise the questions in the SP2 to determine whether specific questions were contributing to the observed SMP, or whether specific questions were unique to a subtype.

In the literature, children with ataxic and dyskinetic CP are sometimes classified as having movement disorders.[144] For analytical purposes, these subtypes were grouped together as the “movement disorders”, and then compared to the “spastic disorders”, that is, the diplegic and hemiplegic subtypes. The reason for this was to determine whether there were differences between the SMP of these two CP classifications.

The spastic subtypes have different anatomical lesions and clinical presentations. The researcher also compared the spastic diplegic and spastic hemiplegic subtypes to determine whether there were statistically significant differences between the two subtypes.

The process of sensory modulation is influenced by several factors, including age, genetics, and environment. The Ecological Human Performance Framework was considered when analysing the results. Therefore, various variables were investigated to determine their influence on sensory modulation in children with CP. Although several contextual factors were available for examination, the researcher chose to focus on a few key factors. These factors were GMFCS levels I-III; age (younger i.e., 5.00 to 9.11 years old and older i.e., 10.00 to 14.11 years old); gender; duration of gestation (premature and full-term delivery); and birth weight (lower than normal birth weight (LNBW) i.e., <2500g and normal birth weight (NBW) i.e., >2500g).

5.5.2.2 Analytical measures

Basic descriptive statistics were used to describe the sensory modulation patterns (quadrants), sensory systems, and behavioural responses in the CP sample (objective 1-3) and in the different subtypes (objective 4-6). The descriptive statistics included the Sd, means, bar and whisker box plots, percentages and confidence intervals (CI). Percentages were used to describe the other variables in the study.

Inferential statistical methods were used to compare the sensory modulation patterns (quadrants) (objective 4), sensory systems (objective 5), and behavioural responses (objective 6) in the different subtypes of CP. The biostatistician used STATA 15.1 to determine if statistically significant differences occurred between the different subtypes. There were five CP subtypes in the study; however, due to a small sample size, the spastic quadriplegic subtype was not included in the inferential statistical analysis.

Inferential statistical tests were also used to determine whether there were statistically significant differences between the different variables. Different statistical methods were used based on the type of data being analysed. All statistical tests were evaluated at 5% level of significance. The following measures were used:

- A **one-way Analysis of Variance (ANOVA) test** was based on the mean total raw scores and was used to compare the quadrants (objective 4) of the four subtypes, as well as the quadrants of the three GMFCS levels. The ANOVA test assumes normality in the data.
- The **Kruskal-Wallis equality of populations rank test** was also based on the mean total raw scores and was used to determine whether differences occurred between the sensory systems and behavioural responses in the different CP subtypes (objective 5-6), as well as in the three GMFCS levels. This test was also used to compare whether there were differences between the questions in the different subtypes, as well as between the different variables. This test was selected over the ANOVA due to skewness in the data or possible outliers, which would have invalidated the results of the ANOVA.
- The **two-sample t-test with unequal variances** was used to compare the mean total raw scores of the quadrants, sensory sections, and behavioural sections in the movement vs spastic disorders, age, gender, duration of gestation, and birth weight groups.
- The **Mann-Whitney test** was used to compare whether there were differences in the questions between the spastic diplegic and spastic hemiplegic subtypes. This test is the two-sample case of the Kruskal-Wallis test.
- The **Fisher's exact test** was used to determine whether there were statistically significant differences between the proportions of participants scoring outside of the norm (outside of the "Just Like" band) in the different subtypes. It was also used to compare the proportions in the movement vs spastic disorders, GMFCS, age gender, duration of gestation, and birth weight groups.
- Lastly the **z-test for proportions** was used to compare the proportions of participants scoring outside of the norm in the different subtypes, as well as in the different GMFCS levels. The z-test differs from the Fisher's exact test in that it compares whether differences occur between each of the subtypes. In contrast, the Fisher's exact test compares the subtypes in relation to the whole sample.

Although the z-test of proportions is a useful tool to compare two subtypes, it only identifies differences between those two groups.

- A **factor analysis** was also conducted on the quadrants to determine whether unique clusters existed in the data.
- **Pearson's correlations** were calculated to determine the strength of the relationship between the quadrants.

3.6 ETHICAL AND LEGAL CONSIDERATIONS

3.6.1 Ethical clearance

Ethical clearance was obtained from the Faculty of Health Sciences Research Ethics Committee, University of Pretoria, certificate number 313/2017 (Appendix O). Other clearance and permission to conduct the research study was obtained by the:

- Postgraduate Research Committee of the Healthcare Sciences Faculty of the University of Pretoria (Appendix P).
- Gauteng Department of Education (GDE) (Appendix Q).
- School principals (Appendix D).
- School governing bodies (Appendix E).
- School-based occupational therapists (Appendix F).

3.6.2 Informed consent

Informed consent (Appendix G) was obtained from the parents/guardians of the learners who were selected to participate in the study. The researcher made it clear that their participation in the study was voluntary, that they could withdraw from the study at any stage, and that there would be no adverse consequences for doing so. This information was conveyed telephonically, as well as in writing. Although the study involved the learners, they were not directly involved, and therefore assent was not obtained from them. Furthermore, informed consent was obtained from parents/guardians to provide a copy of the summary report to the treating therapist at the school (Appendix M). All consent forms were kept in sealed envelopes, together with the completed questionnaires, and locked in a cupboard.

3.6.3 Beneficence and non-maleficence

The study followed sound methodological and ethical principles to ensure no harm was done to the participants. The findings of the SP2 were disclosed to the parents/guardians in the form of a summary report (Appendix N). This report was only made available to the treating school-based therapist if the parents/guardians returned the consent form.

3.6.4 Justice, honesty and veracity

The researcher tried to be as fair as possible in the selection process. The parents/guardians of the learners who met the criteria were given an opportunity to participate in the study. The researcher was honest with all parents/guardians throughout the research process, and the they were not misinformed or deceived in any way. The researcher was truthful about the results and scores obtained from the SP2. The results were not adjusted to suit the needs of the study.

3.6.5 Confidentiality and fidelity

Once the school-based therapists had identified the potential candidates from the school class lists, they then returned a candidate sheet to the researcher. This sheet contained the name, date of birth, GMFCS level and CP classification of each candidate. Only the researcher had access to this document. The learners were then coded with a research number to ensure anonymity and eliminate bias. Only the researcher had access to these codes. It was important to know the identity of the participants to provide them with a copy of their SP2 results.

The questionnaires were returned in sealed envelopes to ensure that the information remained confidential. All written communication with the parents/guardians was sealed in the envelopes. Personal information was not transferred to data-recording spreadsheets. The details of participants and schools will remain anonymous. All confidential information will be stored in a locked cabinet at the University of Pretoria, as per the requirements of the Protection of Personal Information Act.

3.6.6 Right to information and intervention

Each parent/guardian that participated in the study was provided with a summary report (Appendix N) based on the results of the SP2. This report was compiled by the researcher based on the participant's results. Due to a large number of participants the researcher chose to disclose the results in the form of a report, rather than in person. The researcher used simple language to convey the results, as well as definitions to ensure that the parents/guardians could understand the results. If the learner was identified as having possible sensory modulation difficulties, further occupational therapy evaluation and intervention was advised. Since all the schools have occupational therapists available, this did not place any additional burden on the parents/guardians. If permission was provided, the researcher also provided a copy of the participant's results to the treating therapist so that suitable intervention could be provided at school. The report also included some strategies for the parents, teachers, as well as the therapists. The parents/guardians were informed that they could contact the researcher after the study if they required further information regarding the assessment results and possible intervention.

3.7 SUMMARY OF METHODOLOGY

A quantitative, non-experimental, comparative-descriptive design was selected to meet the research aim, objectives and hypotheses. Convenience sampling was used to identify participants from five LSEN schools in Johannesburg. The parents/guardians of the identified learners (based on strict inclusion criteria) completed the SP2 questionnaire. The methodological procedures pertaining to this study were discussed in this chapter, including the research design, sample, measurement instruments, procedure, and data management. The ethical procedures used in this study were also detailed. The results of descriptive and inferential statistical procedures will be discussed in chapter four.

CHAPTER 4
RESEARCH RESULTS

4.1 INTRODUCTION

This chapter will provide the results of the research study. The researcher will provide the demographic data pertaining to the participants and the parents/guardians in the study in section 4.2. Section 4.3 will portray the results relating to the six main objectives. Section 4.3.1-4.3.3 will examine the results pertaining to the quadrants, sensory sections, and behavioural sections in the CP sample (objectives 1-3). Section 4.3.4-4.3.6 will compare the quadrants, sensory sections, and behavioural sections in the different CP subtypes (objectives 4-6) using both descriptive and inferential statistics. Section 4.4. will examine other findings, that is, movement disorders versus spastic disorders, GMFCS levels, age, gender, duration of gestation, and birth weight. Although these variables were not originally identified as objectives in the study, they were considered to influence sensory modulation in children with CP; therefore, they were considered to be pertinent to the paper. Section 4.5. will summarise the results.

4.2 DEMOGRAPHIC DATA RESULTS

This section will examine the demographic data from the study to contextualise the results. The demographic data will be discussed in two sections. The first section pertains to the participants and will include the age, gender, classification, birth history, associated impairments, and the educational status. The second section pertains to the parents/guardians and will include the home language and the educational status.

4.2.1 Demographic data pertaining to the participants

4.2.1.1 Age and gender

The mean age of the sample was nine years, five months (table 4.1). More than fifty percent (56.49%) of the sample were in the younger group (n=87) and 43.50% were in the older group (n=67). Therefore, there were more younger children in the study.

Of the 154 participants in the study, 61.04% were male (n=94), and 38.96% were female (n=60), which is depicted in table 4.1. There were more males in all the subtypes, that is, 52.38% in the ataxic subtype, 57.38% in the spastic diplegic subtype, 59.18% in the hemiplegic subtype, and 85.71% in the dyskinetic subtype. Most of the GMFCS levels had predominantly male participants, that is, 68.89% (n=31) in level I, 52.54% (n=31) in level II, and 64.00% (n=32) in level III (table 4.2).

Table 4.1 Age and mean age of the sample

Class	**All**		**A**		**DY**		**SD**		**SH**		**SQ**	
Gender	M	F	M	F	M	F	M	F	M	F	M	F
Number (n)	94	60	11	10	18	3	35	26	29	20	1	1
Mean age (years)	9.5	9.6	8.6	9.9	9.4	11.5	9.8	9.4	9.4	9.4	13.2	9.4
	9.54		9.25		9.55		9.67		9.41		11.25	

M=male; F=female; A=ataxic, DY=dyskinetic; SD=spastic diplegic; SH=spastic hemiplegic; SQ= spastic quadriplegic

4.2.1.2 Classification of participants

Figure 4.1 below represents the distribution of the different CP subtypes in the study. From the cohort, 13.64% were classified as ataxic CP (n=21), 13.64% were classified as dyskinetic CP (n=21), 39.61% were classified as spastic diplegic (n=61), 31.82% were classified as spastic hemiplegic (n=49), and 1.30% were classified as spastic quadriplegic.

The spastic subtype (n=112) made up 72.72% of the participants. The spastic CP group was comprised of mainly spastic diplegics (54.46%) and spastic hemiplegics (43.75%). There were only two participants classified in the spastic quadriplegic subtype.

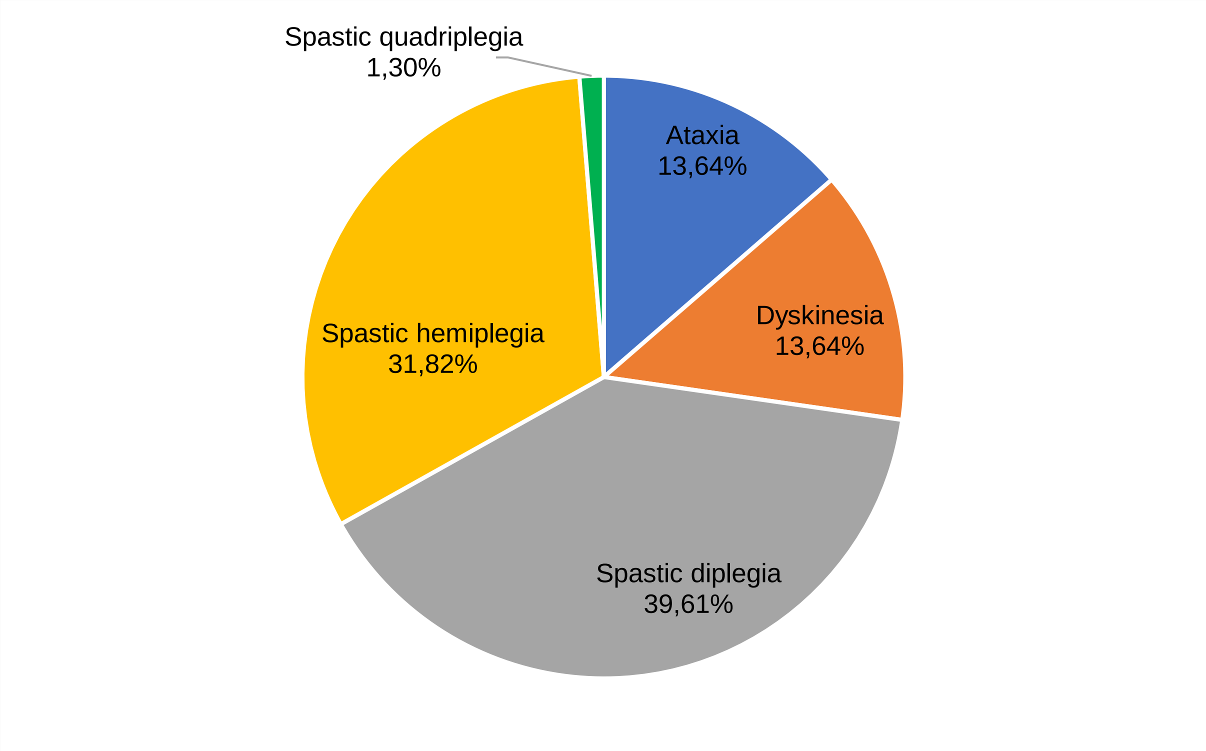


Figure 4.1 Distribution of the participants according to the CP subtypes

Table 4.2 below, shows the distribution of the CP sample according to the GMFCS levels. Of the three GMFCS levels in the study; 29.22% were from GMFCS level I, 38.31% were from GMFCS level II, and 32.47% were from GMFCS level III.

Table 4.2 Distribution of the CP participants according to the GMFCS levels

Subtype	Gender	I	II	III	All	%
A	Male	4	5	2	11	52.38%
	Female	1	8	1	10	47.62%
DY	Male	5	7	6	18	85.71%
	Female	1	1	1	3	14.29%
SD	Male	1	10	24	35	57.38%
	Female	0	11	15	26	42.63%
SH	Male	21	8	0	29	59.18%
	Female	12	8	0	20	40.82%
SQ	Male	0	1	0	1	50.00%
	Female	0	0	1	1	50.00%
All	Male	31	31	32	94	61.04%
	Female	14	28	18	60	38.96%
	Total	29.22%	38.31%	32.47%	154	100.00%

A=ataxic; DY=dyskinetic; SD=spastic diplegic; SH=spastic hemiplegic; SQ= spastic quadriplegic

Figure 4.2 below portrays the prevalence of the three GMFCS levels (I, II, and II) in the different CP subtypes.

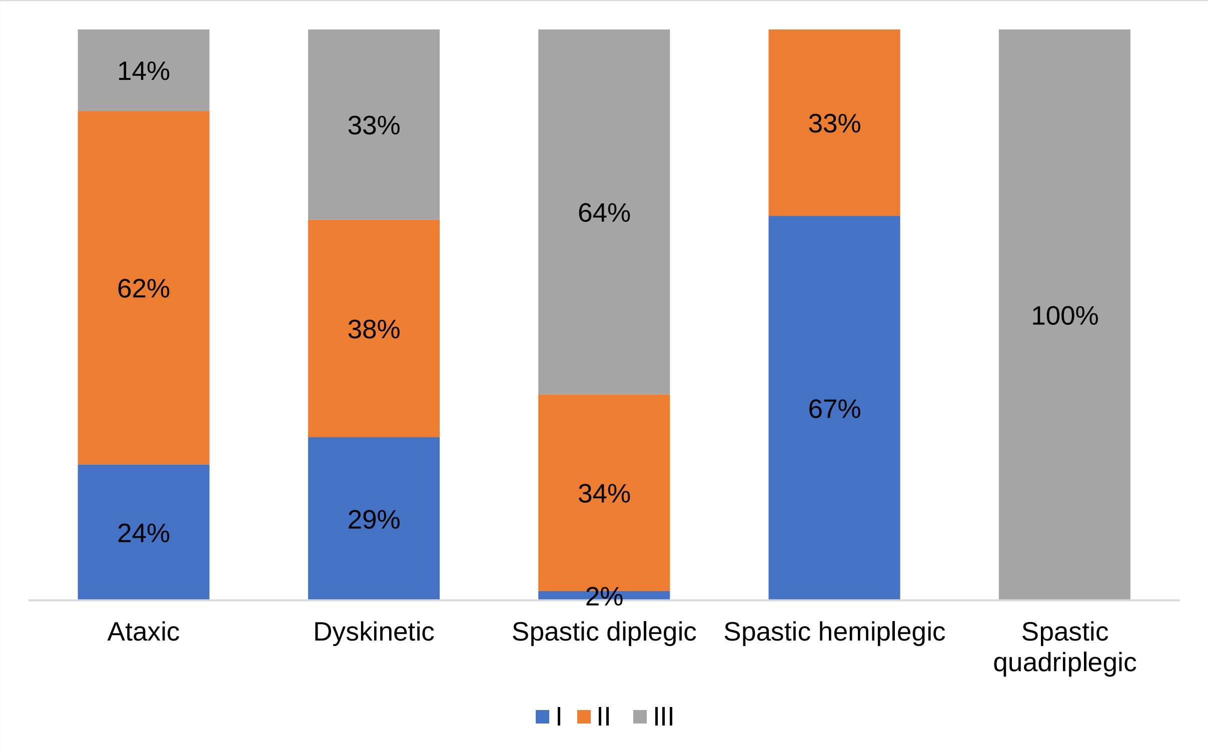


Figure 4.2 Prevalence of the GMFCS I, II, and III levels within each CP subtype

Most of the ataxic subtype (61.90%) were classified in GMFCS level II, indicating that they walked with some difficulty. The dyskinetic subtype had participants in all three levels, with most being classified in GMFCS level II (38.10%) and III (33.33%). The majority of the spastic diplegic subtype (63.93%) were in GMFCS level III, indicating that they required an assistive device to walk. The spastic hemiplegic subtype (67.35%) were mostly classified in GMFCS level I, indicating that they had minimal walking deficits. Both spastic quadriplegic participants were in the level III group.

4.2.1.3 Birth history

Figure 4.3 illustrates the birth history findings, including the type of pregnancy, birth weight, type of delivery, as well as complications. More than half of the participants (66.23%) were delivered at full term, with 27.92% reportedly born prematurely. Most of the participants (53.90%) had a NBW, but there was quite a high percentage born underweight (25.98%). In the <2500g birth weight bands, 14.94% had a LBW, 3.90% had a VLBW, and 7.14% had an ELBW.

Thirty-six percent (36.36%) of the parents/guardians indicated that they experienced problems during their pregnancy, whereas the majority had some difficulty during the birth (60.39%), or postnatally (66.88%). High blood pressure (18.18%) was the most common problem during pregnancy. Difficulties during the birthing process included: the baby did not cry (31.82%), the baby was put in an incubator (33.77%), or the baby needed oxygen (31.82%). Respiratory problems such as pneumonia or bronchitis occurred in 26.62% of participants, jaundice in 25.32% of participants, and epilepsy/seizures in 20.13% of participants postnatally.

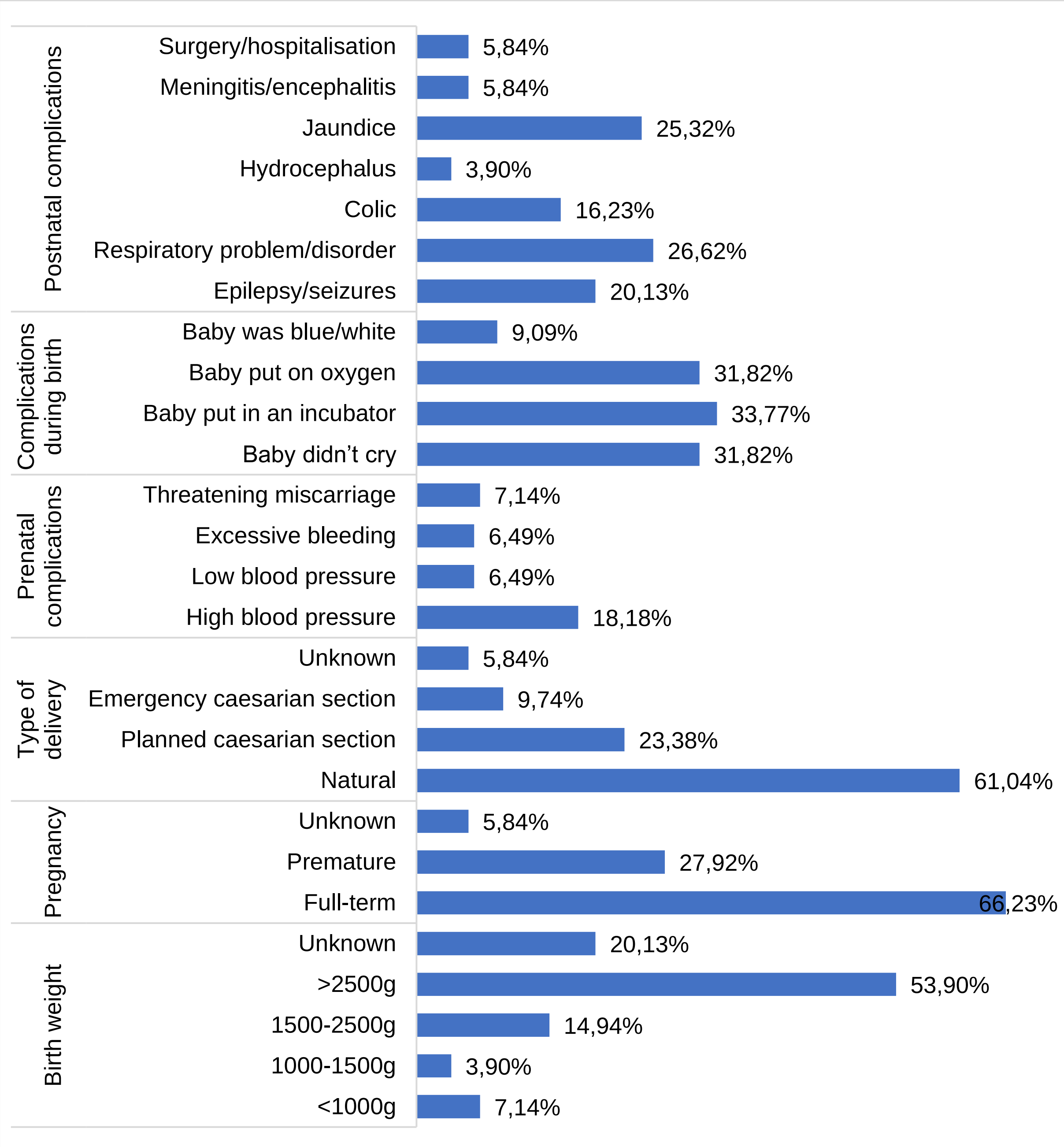


Figure 4.3 Birth weight, pregnancy, delivery and problems

4.2.1.4 Associated impairments of the participants

Figure 4.4 represents the reported associated impairments of the participants in the study. The most commonly mentioned impairments were communication difficulties (47.40%), visual problems (29.22%), and epilepsy (14.90%). Less than 10 percent of the participants presented with hearing problems (9.74%), behavioural/attentional difficulties (3.24%), or allergies (7.79%).

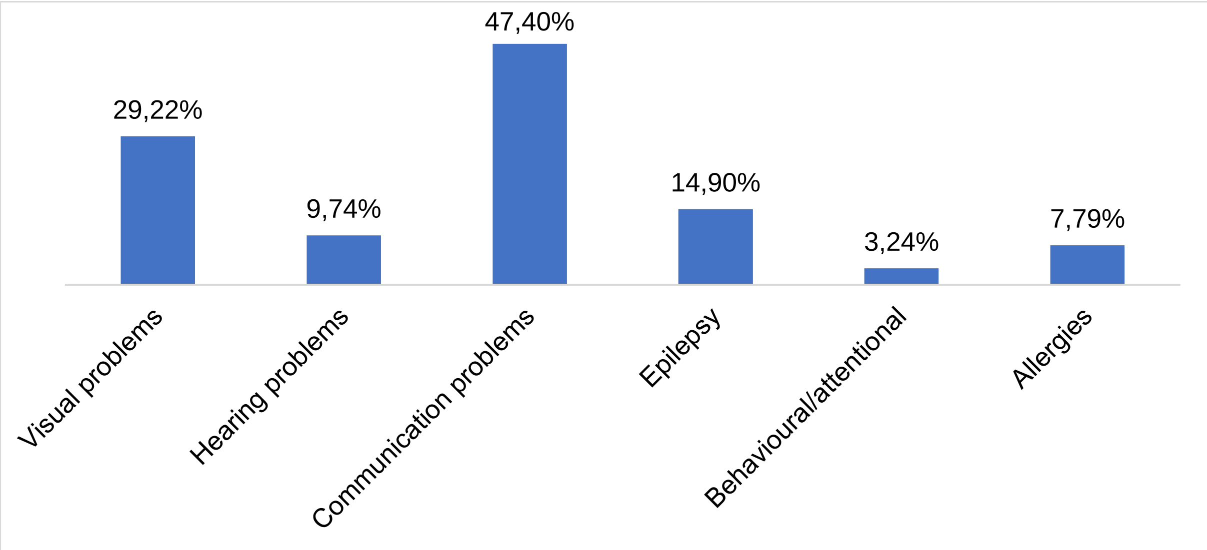


Figure 4.4 Percentage of associated impairments in the CP sample

4.2.1.5 Educational status of the participants

The level of education of the participants is represented in table 4.3. The majority (79.87%) of the participants were from the academic/mainstream section of their school, with a smaller percentage (20.13%) coming from the modified/special section. The modified section includes learners who follow an adapted CAPS curriculum.

Table 4.3 Section/grade at school

Grade/section	Number of responses (n)	Percentage (%)
R	53	34,42%
1	22	14,29%
2	16	10,39%
3	12	7,79%
4	14	9,09%
5	4	2,60%
6	2	1,30%
Modified section	31	20,13%

4.2.2 Demographic data pertaining to the parents/guardians

4.2.2.1 Home language of the parents/guardians

Table 4.4 reflects the home languages spoken by the parents/guardians. Most of them spoke an African language, including Zulu (28.87%), Sotho (12.99%), Tswana, (10.39%), and Xhosa (10.39%). Approximately fifteen percent (14.98%) of the respondents indicated that English was their home language, and 12.34% of the sample were Afrikaans speaking. Close to half (42.86%) of the parents/guardians selected English as their second or third language.

Table 4.4 Home languages

Home language	Number of responses (n)	Percentage (%)
Zulu	46	29.87%
English	23	14.94%
Sotho	20	12.99%
Afrikaans	19	12.34%
Tswana	16	10.39%
Xhosa	16	10.39%
Pedi	5	3.25%
Tsonga	4	2.60%
Venda	2	1.30%
French	1	0.65%
Ndebele	1	0.65%
Swazi	1	0.65%

4.2.2.2 Educational status of the parents/guardians

Table 4.5 represents the highest level of education (HLOE) of the parents/guardians in the study. Most of the mothers had a high school education, with 44.81% completing Matric. Some of the mothers (16.89%) had tertiary education. There was limited information regarding the father's HLOE, often because the father was not involved in the child's life, or the parent chose not to disclose this information. From the information that was provided, 43.51% of the fathers had a high school level of education, with 28.57% completing Matric.

Table 4.5 HLOE of parents/caregivers

Highest level of education	Mother		Father	
	n	%	n	%
Grade 8-11	38	24.68%	23	14.94%
Matric	69	44.81%	44	28.57%
Certificate/diploma	21	13.64%	11	7.14%
Degree	5	3.25%	5	3.25%
Unknown	21	13.64%	71	46.10%

The next section will examine the results related to the specific objectives. Objectives 1-3 pertain to children with CP, and 4-6 pertain to the different subtypes.

4.3 RESULTS PERTAINING TO THE OBJECTIVES

4.3.1 Sensory modulation patterns in cerebral palsy

The first objective was to describe the predominant sensory modulation pattern(s) in the quadrants in children with CP.

Figure 4.5 represents the spread of the data in the four quadrants. The "X" represents the mean (average) total raw score. The dashed line represents the boundary between scores in the "More" and "Just Like" bands. The solid black line represents the boundary between the "Less" and "Just Like" bands.

The registration quadrant had the highest mean, followed by the avoiding quadrant. The seeking, avoiding, and sensitivity quadrants had similar interquartile ranges; thereby, indicating similar dispersions in the data. The registration quadrant had the longest box; however, the overall range was greater in the seeking and avoiding quadrants, due to the longer tails, as well as the outlier in the seeking quadrant. Since the mean and median (solid line within the box) were close to each other in all the quadrants, it can be assumed that the data is reasonably symmetric. The mean scores in the avoiding (48.43), sensitivity (43.40), and registration (55.83) quadrants were above the dashed line; therefore, falling outside of the norm. The registration quadrant was further from the dashed line than the other quadrants, indicating that more participants fell outside of the norm. Some participants fell below the solid black line ("Less" band) in the seeking and the avoiding quadrants.

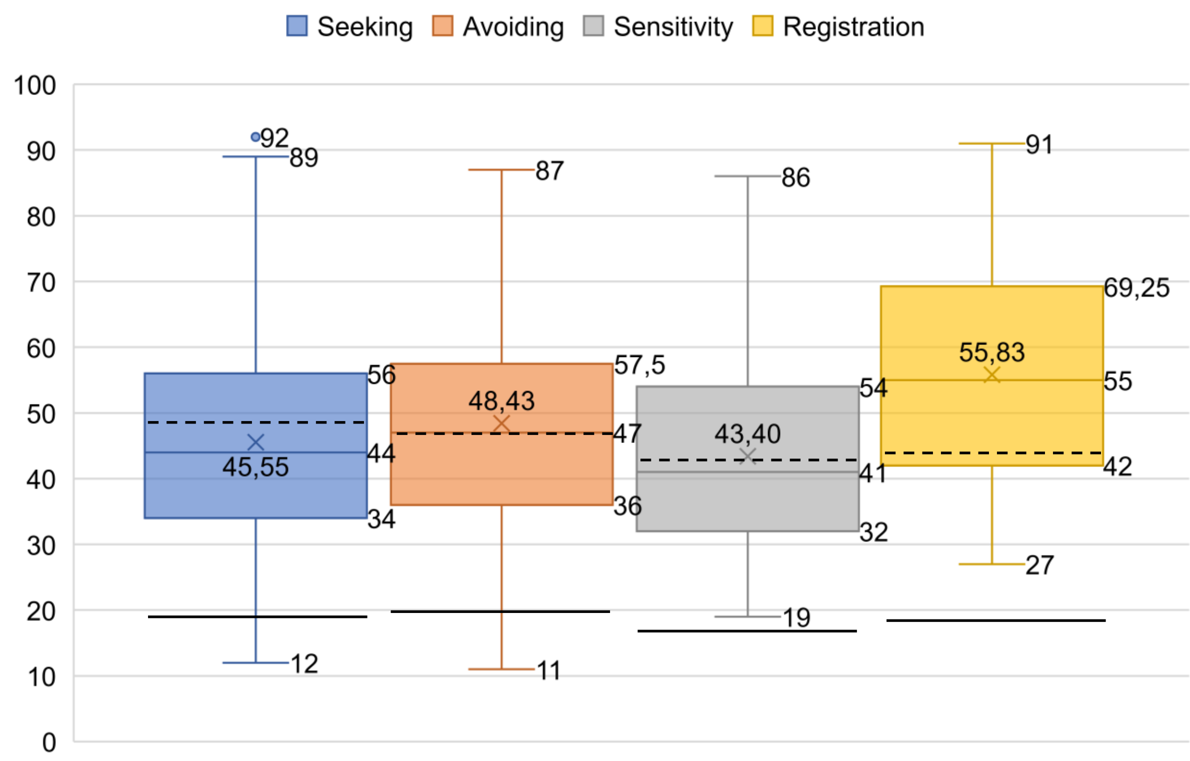
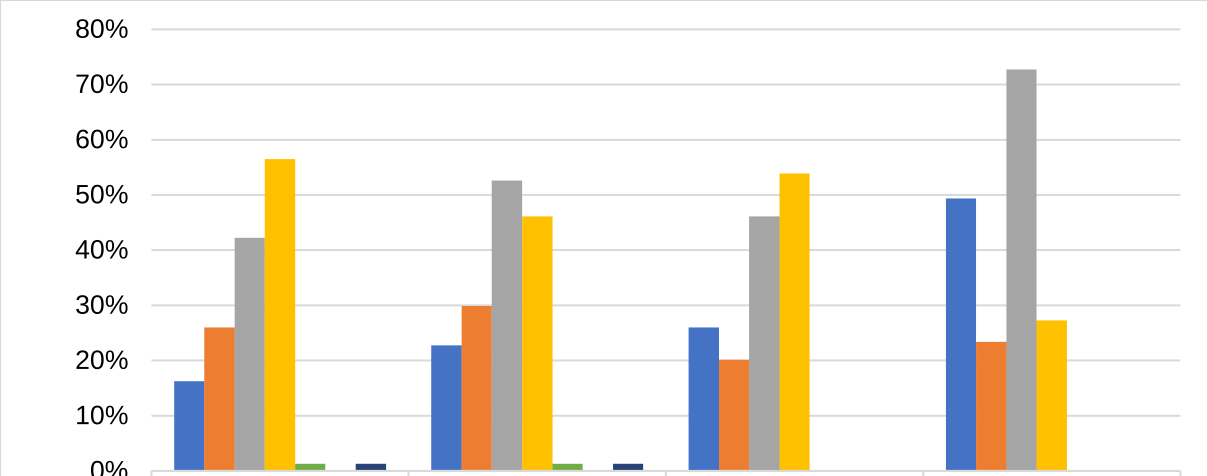


Figure 4.5 Box and whisker plot of the quadrant scores in all CP subtypes

Figure 4.6 below represents the percentage of children who scored in the different bands in the SP2. The registration quadrant had the highest percentage (72.73%) of participants scoring in the "More" band, followed by the avoiding quadrant (52.60%). The seeking (56.49%) and sensitivity (53.90%) quadrants had more participants scoring in the "Just Like "band. More participants scored in the "Much More" band than the "More Than" band in the sensitivity and registration quadrants. Very few participants scored in the "Less Than" band in all of the quadrants. None of the participants scored in the "Much Less" band in any of the quadrants.

The majority of CP participants (80.25%) presented with atypical SMP, whereby one or more quadrants scored more than 1Sd from the mean. Of those, 20.13% scored out of the norm in one quadrant, 14.94% in two quadrants, 15.58% in three quadrants, and 29.87% in all four quadrants. When combining the "More" and "Less" percentages, the registration (72.73%, CI = ±7.03) and avoiding (53.90%, CI= ±7.87) patterns were most frequently observed; while the sensitivity (46.10%, CI= ±7.87) and seeking (43.51%, CI= ±7.83) patterns were least frequently observed.



	Seeking	Avoiding	Sensitivity	Registration
MM	16,23%	22,73%	25,97%	49,35%
MT	25,97%	29,87%	20,13%	23,38%
More	42,21%	52,60%	46,10%	72,73%
JL	56,49%	46,10%	53,90%	27,27%
LT	1,30%	1,30%	0,00%	0,00%
ML	0,00%	0,00%	0,00%	0,00%
Less	1,30%	1,30%	0,00%	0,00%

MM="Much More"; MT="More Than"; JL="Just Like"; LT="Less Than"; ML="Much Less"

Figure 4.6 Distribution of participants in the different quadrants for all CP subtypes

In a normal distribution, one would expect approximately 68% of participants to fall between -1Sd and +1Sd, and approximately 32% of participants to fall more than 1Sd from the mean on either end of the bell curve. In contrast, significantly higher proportions ($p<0.000$) of children with CP in the sample fell out of the norm in all four quadrants in comparison to the normative data obtained from the SP2 manual.

Figure 4.7 below indicates the preferred neurological thresholds and self-regulatory strategies from Dunn's Sensory Processing Framework in children with CP. Two quadrants make up each of the four factors, which are, active (seeking and avoiding quadrants), passive (sensitivity and registration quadrants), high (seeking and registration quadrans), and low (avoiding and sensitivity quadrants).

The percentages below represent participants that fell out in the two quadrants which make up a factor. All four of the factors occurred in less than 50% of participants. The passive strategy was observed in 42.86% of participants, with the active strategy

(35.06%) occurring less frequently. The high threshold (40.91%) and low threshold (39.61%) occurred in similar proportions, with the high threshold slightly higher than the low threshold. There were no significant differences between these factors.

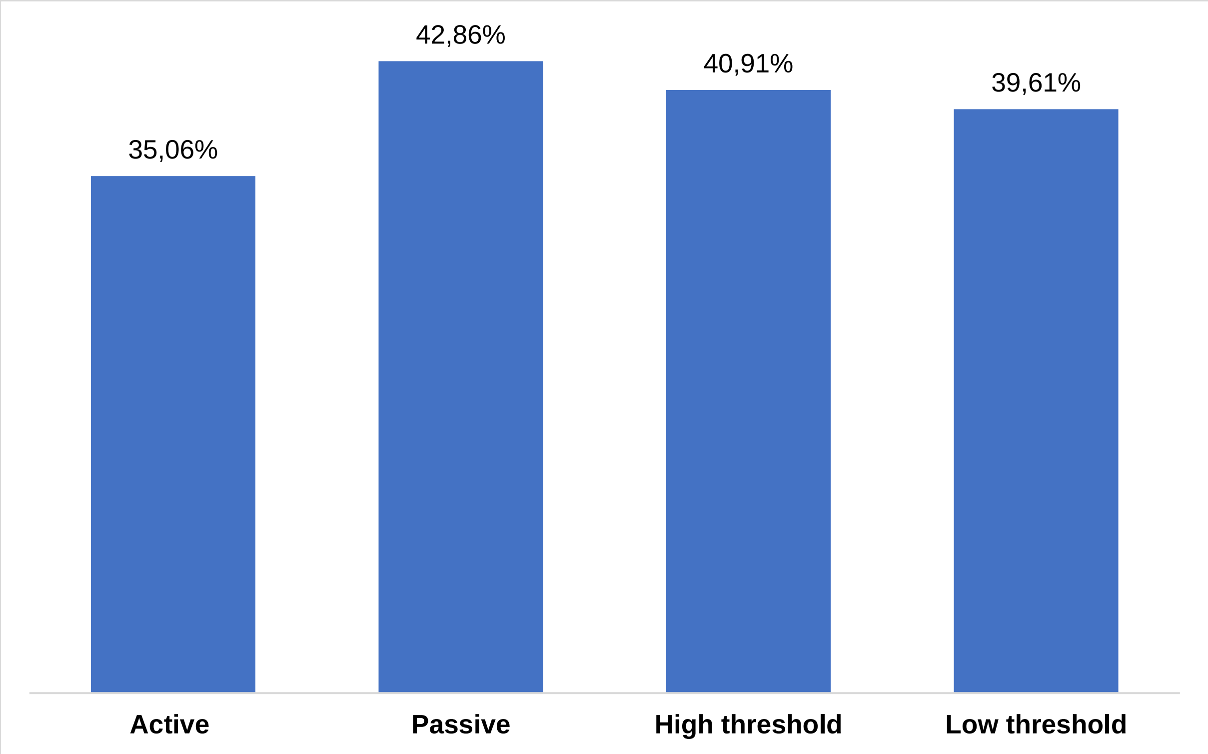


Figure 4.7 Predominant neurological thresholds and self-regulatory strategies in children with CP

A factor analysis was done to determine whether there were any relationships between the quadrants. Similar methods were used in other studies.[23,127] The factor analysis revealed that there were no real factors or clusters in the four quadrants, as reflected in the scatterplot (figure 4.8).

However, the scatterplot does indicate that all the pairs of quadrants (every combination of two out of the four quadrants) have a positive, linear relationship with each other. This relationship indicates that participants who score high in one quadrant will probably also have high scores in other quadrants. The inverse is also true, whereby children who score low in one quadrant will probably also score low in other quadrants.

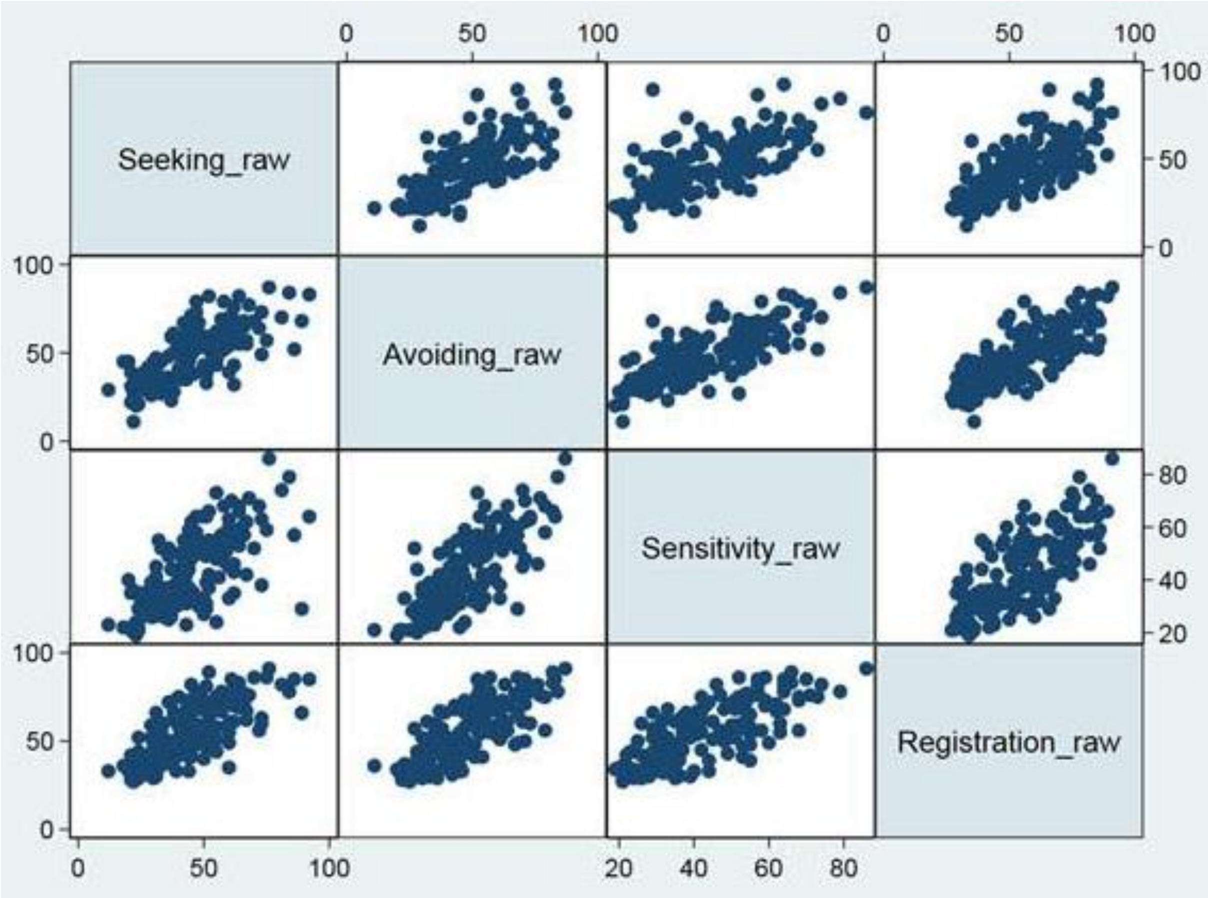


Figure 4.8 Scatterplots of all the quadrant scores

To confirm the relationship between the quadrants a Pearson's correlation was done between the quadrant scores. Table 4.6 represents the correlations between the four quadrants. These correlations indicate the strength of the relationship between the pairs of quadrants. The values were all high, indicating that the correlations are strong. Therefore, there is a strong positive linear relationship between the four quadrants.

Table 4.6 Pearson's correlations between scores

	Seeking	**Avoiding**	**Sensitivity**	**Registration**
Seeking	1.0000			
Avoiding	0.7110	1.0000		
Sensitivity	0.6793	0.7861	1.0000	
Registration	0.7299	0.7431	0.7323	1.0000

4.3.2 Sensory modulation in the sensory systems in cerebral palsy

The second objective was to describe the quality of sensory modulation in the six sensory systems.

Figure 4.9 provides a visual representation of the overall spread of data in the sensory systems. The means and medians were similar in all the sensory sections; therefore, representing a relatively normal distribution. There was a higher range in the oral sensory and touch sensory sections, indicating more variability in these data sets. There were also two outliers in the touch processing section. The means for the movement (20.56) and body position (23.18) processing sections were above the dashed line; therefore, suggesting that they fell outside of the norm. The means in the auditory (21.99), visual (15.42), touch (21.63), and oral sensory (23.88) systems fell within the norm. Some of the participants fell in the “Less” band in the visual, touch, and oral sensory processing sections.

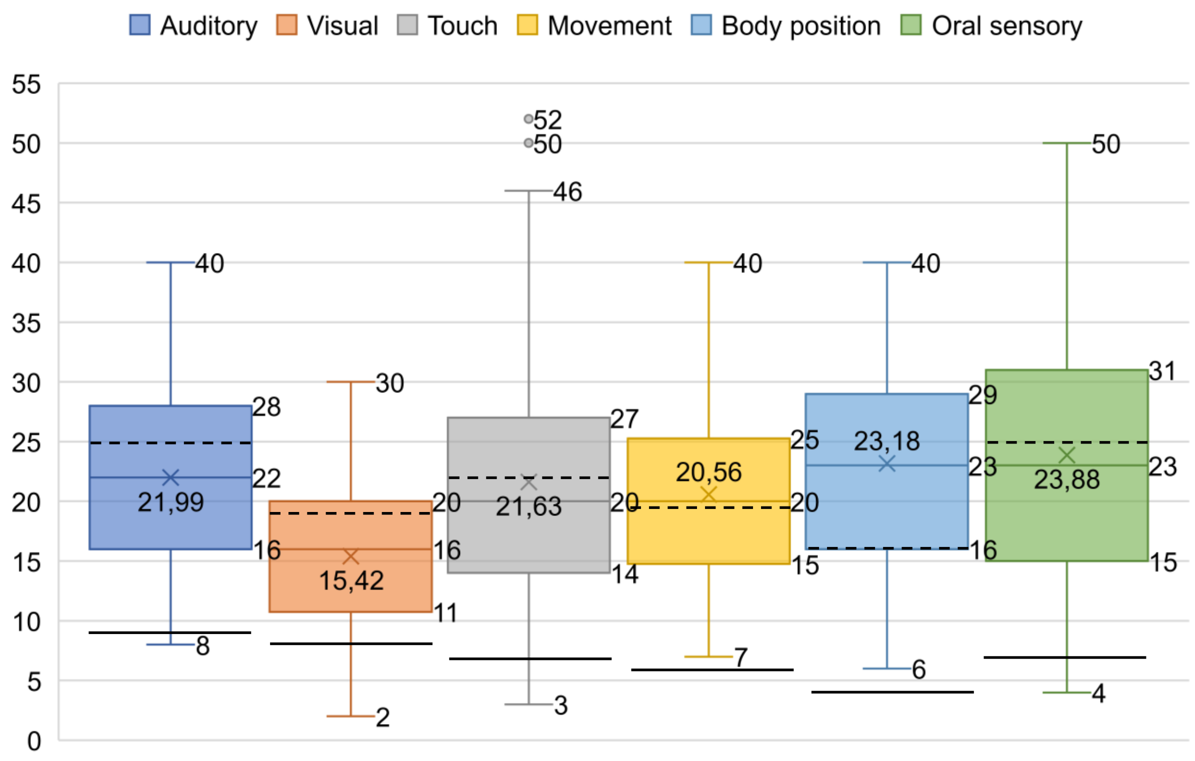
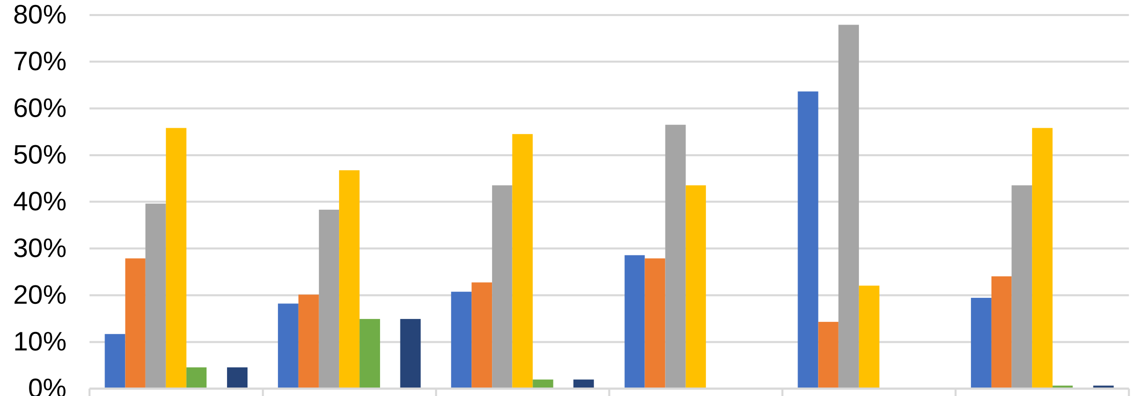


Figure 4.9 Box and whisker plot of the sensory section scores in all CP subtypes

Figure 4.10 below shows the percentage distribution for the different sensory sections. The body position system had the highest percentage (77.92%) of participants scoring in the “More” band, followed by the movement system (56.49%). More participants fell in the “Much More” band than the “More Than” band in these two sensory systems. Most of the participants scored in the “Just Like” band in the auditory (55.84%), touch (54.55%), and oral sensory (55.84%) processing systems. The visual sensory system had the highest percentage of participants scoring in the “Less Than” band. Children who score in the “Less Than” or “Much Less” bands may also have difficulties according to the SP2 manual.



	Auditory	Visual	Touch	Movement	Body position	Oral sensory
MM	11,69%	18,18%	20,78%	28,57%	63,64%	19,48%
MT	27,92%	20,13%	22,73%	27,92%	14,29%	24,03%
More	39,61%	38,31%	43,51%	56,49%	77,92%	43,51%
JL	55,84%	46,75%	54,55%	43,51%	22,08%	55,84%
LT	4,55%	14,94%	1,95%	0,00%	0,00%	0,65%
ML	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Less	4,55%	14,94%	1,95%	0,00%	0,00%	0,65%

MM=”Much More”; MT=”More Than”; JL=”Just Like”; LT=”Less Than”; ML=”Much Less”

Figure 4.10 Distribution of participants in the different sensory systems for all CP subtypes

Almost all (94.16%) the participants had trouble in one or more sensory systems. Atypical scores in 1-2 sensory systems occurred in 31.82% of participants, atypical scores in 3-4 sensory systems occurred in 35.71% of participants, and 26.62% of participants had atypical scores in 5-6 sensory systems. When adding the “More” and “Less” bands, most of the children presented with body position (77.92%, CI= ±7.02), movement (56.49%, CI= ±7.83), and visual processing (53.25%, CI= ±7.88) difficulties. Less than 50% presented with auditory (44.16%, CI= ±7.84), touch (45.45%, CI= ±7.86), and oral sensory (44.16%, CI= ±7.84) processing difficulties. A significantly higher proportion of participants (p<0.000) fell out of the norm in all the sensory systems in comparison to the normal population.

4.3.3 Behavioural responses associated with sensory modulation in cerebral palsy

The third objective was to describe the predominant behavioural patterns in children with CP.

Figure 4.11 below represents the spread of data in the behavioural section. The means and medians were fairly similar in all the behavioural sections, indicating that the data was relatively normally distributed. There was a large spread in the social-emotional section, indicating that there was more variability in the data set. There was one outlier in the attentional section. The social-emotional mean (34.67) fell above the dashed line; therefore, falling in the "More" band. In contrast, the conduct (20.10) and attentional (23.46) means fell below the line; therefore, falling in the "Just Like" band. Some participants scored in the "Less" band in the social-emotional section.

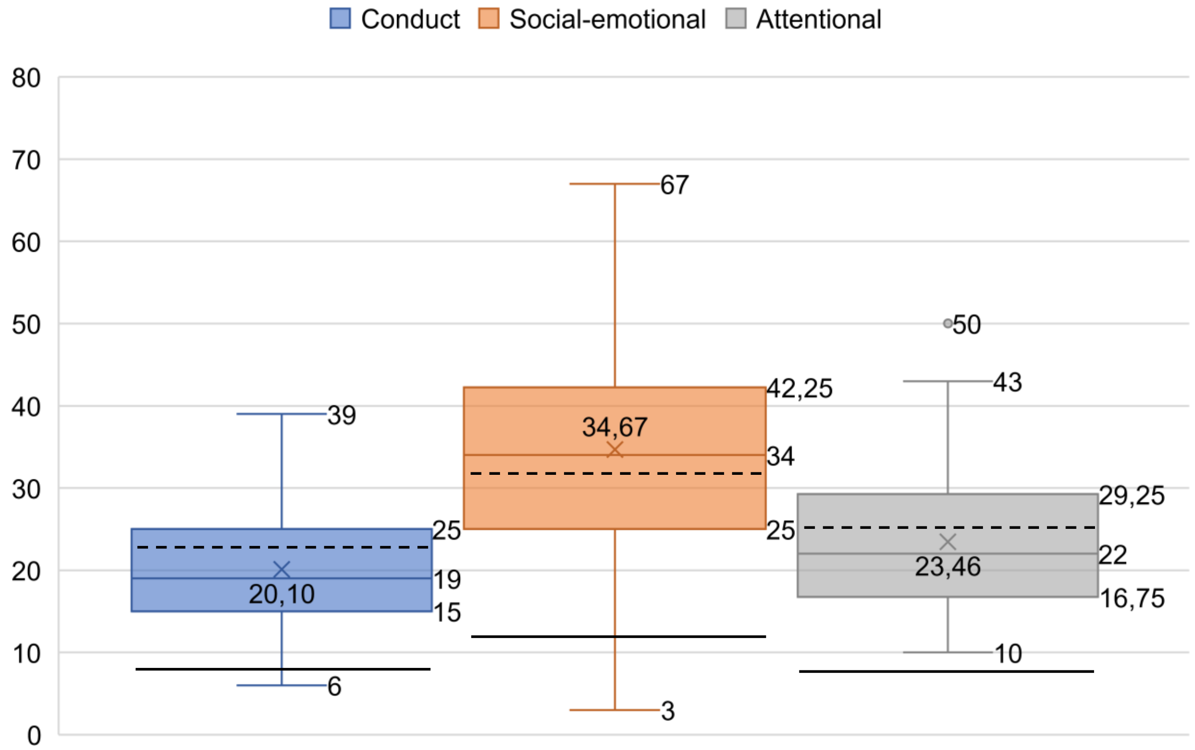
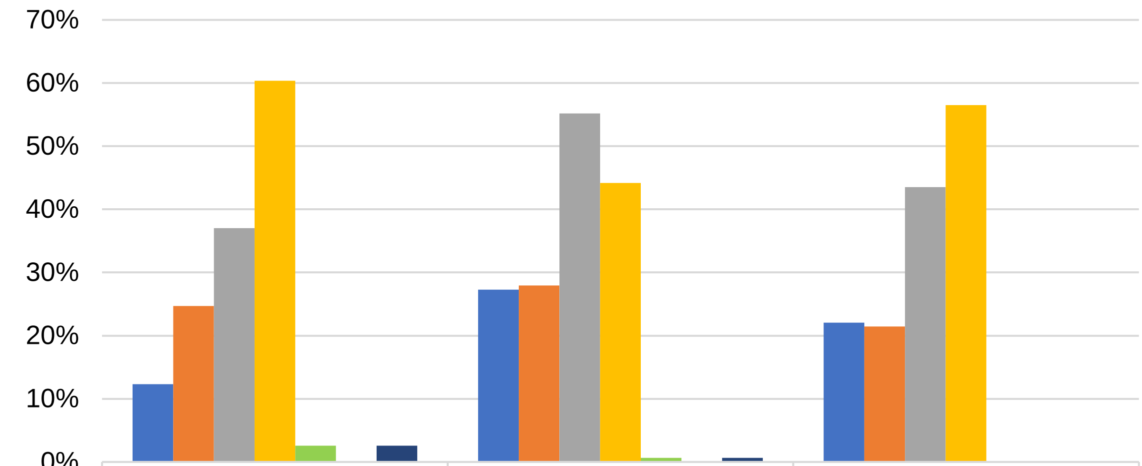


Figure 4.11 Box and whisker plot of the behavioural section scores in all CP subtypes

In the below graph (figure 4.12) the percentage distribution for the behavioural sections is displayed. Most of the participants scored in the “Just Like” band in the conduct (60.39%) and attentional (56.43%) sections. The majority of participants (55.19%) scored in the “More” band in the social-emotional section.



	Conduct	Social emotional	Attentional
MM	12,34%	27,27%	22,08%
MT	24,68%	27,92%	21,43%
More	37,01%	55,19%	43,51%
JL	60,39%	44,16%	56,49%
LT	2,60%	0,65%	0,00%
ML	0,00%	0,00%	0,00%
Less	2,60%	0,65%	0,00%

MM=”Much More”; MT=”More Than”; JL=”Just Like”; LT=”Less Than”; ML=”Much Less”

Figure 4.12 Distribution of participants in the different behavioural systems for all CP subtypes

More than half of the participants (66.23%) had atypical scores in one or more of the behavioural sections. Of those, 22.08% scored out of the norm in one section, 15.58% in two sections, and 28.57% in all three sections.

Most of the participants presented with social-emotional (55.84%, CI= ±7.84) difficulties when combining the “More” and “Less” scores. Conduct (39.61%, CI= ±7.72) and attentional (43.51%, CI= ±7.83) difficulties were less prevalent. These percentages are all significantly ($p<0.000$) higher in comparison to the normative data in the SP2 manual.

4.3.4 Sensory modulation patterns in different types of cerebral palsy

The fourth objective aimed to compare the quadrant patterns in the different subtypes of CP, namely, the ataxic, dyskinetic, spastic diplegic and spastic hemiplegic subtypes.

Figure 4.13 to 4.16 represent the box and whisker plots of the four quadrants in the different subtype of CP.

The box plot (figure 4.13) for the ataxic subtype was the longest, while the box plots for the diplegic and dyskinetic subtypes were the shortest. However, the diplegic and hemiplegic subtypes had the greatest range in the seeking quadrant because of the longer tails in both subtypes, as well as the three outliers in the diplegic subtype. In the seeking quadrant, the ataxic subtype obtained the highest mean (48.38), which fell above the dashed line; therefore, falling in the "More" band. The means for the dyskinetic (47.52), diplegic (45.90), and hemiplegic (43.14) subtypes fell below the dashed line; therefore, falling within the "Just Like" band. The hemiplegic subtype obtained the lowest mean. A few participants in the hemiplegic subtype fell below the solid black line ("Less" band).

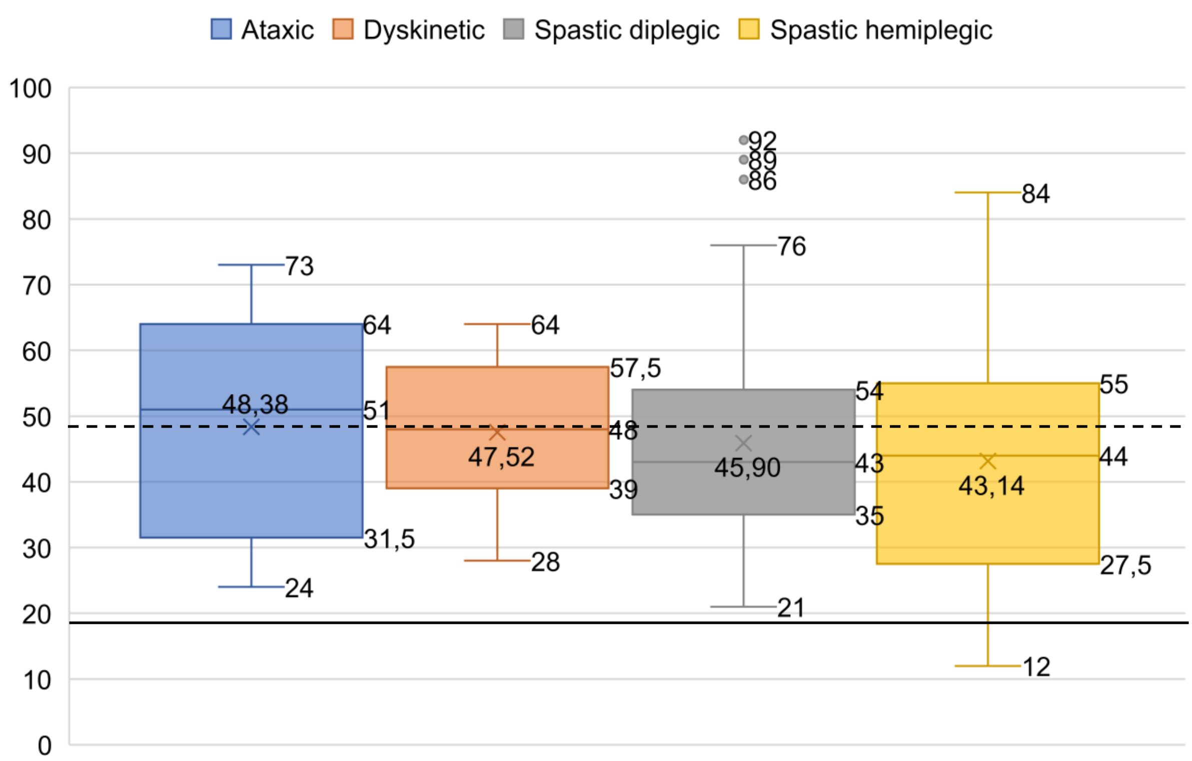


Figure 4.13 Box plot of the seeking quadrant in the different subtypes

In the avoiding quadrant (figure 4.14), the ataxic subtype had the highest mean (52.48) of the four subtypes, while the dyskinetic subtype had the lowest mean (46.38). The mean scores of the ataxic, diplegic (47.36), and hemiplegic (49.47) subtypes fell above the dashed line; therefore, suggesting that these subtypes have difficulty in the avoiding quadrant. The mean score for the dyskinetic subtype fell in the "Just Like" band. Some participants in the hemiplegic subtype scored in the "Less" band, that is, below the solid black line in the avoiding quadrant.

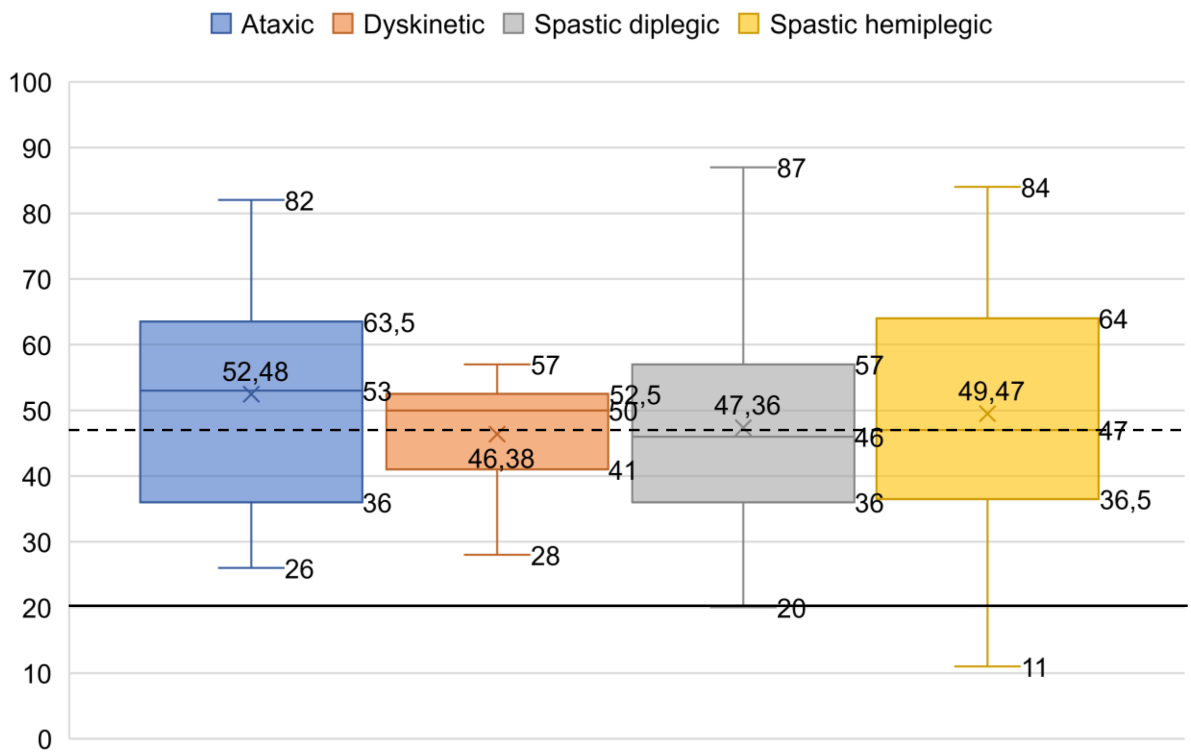


Figure 4.14 Box plot of the avoiding quadrant in the different subtypes

In the sensitivity quadrant (figure 4.15), the mean (48.90) for the ataxic subtype was the highest, falling outside of the norm. The hemiplegic mean score (44.82) also fell outside of the norm. The dyskinetic (41.67) and diplegic (41.31) subtypes had the lowest means, both falling in the "Just Like" band. There was one outlier in the diplegic subtype. Some of the hemiplegic participants scored in the "Less" band.

In the registration quadrant (figure 4.16), the mean scores in all the subtypes were above the dashed line ("More" band). The highest mean (59.24) was obtained by the ataxic subtype, followed by the spastic diplegic subtype, with a mean score of 58.11.

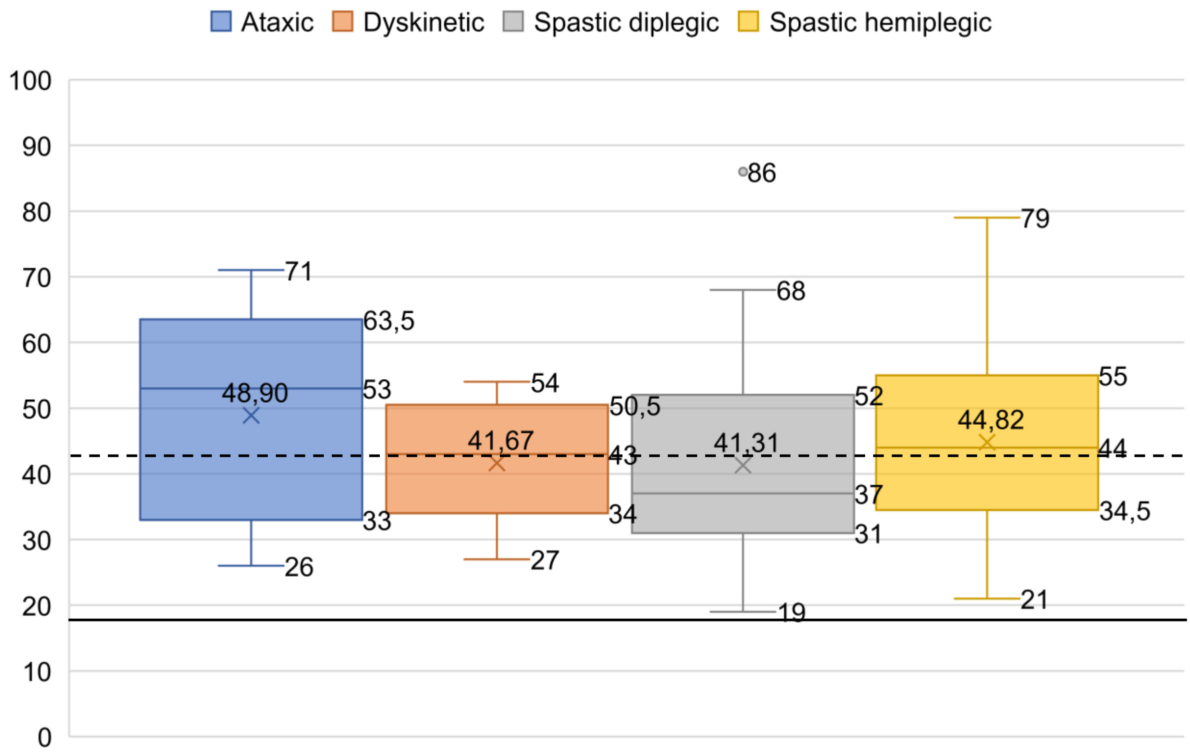


Figure 4.15 Box plot of the sensitivity quadrant in the different subtypes

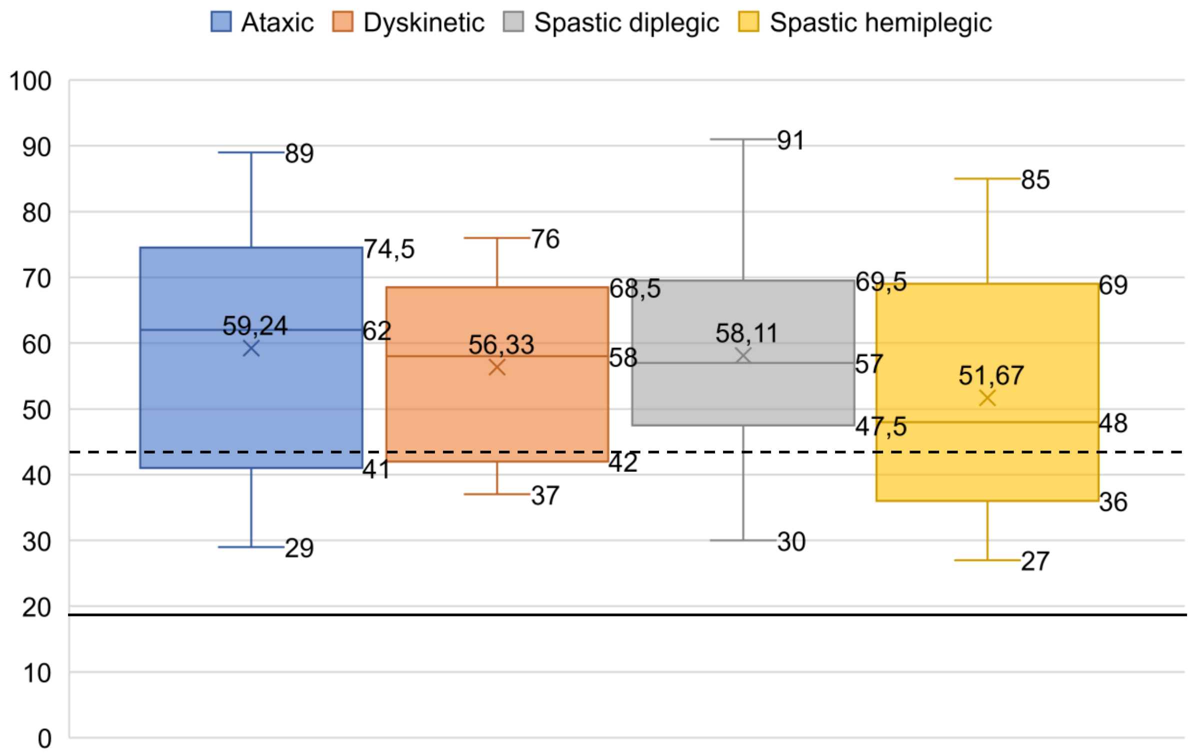


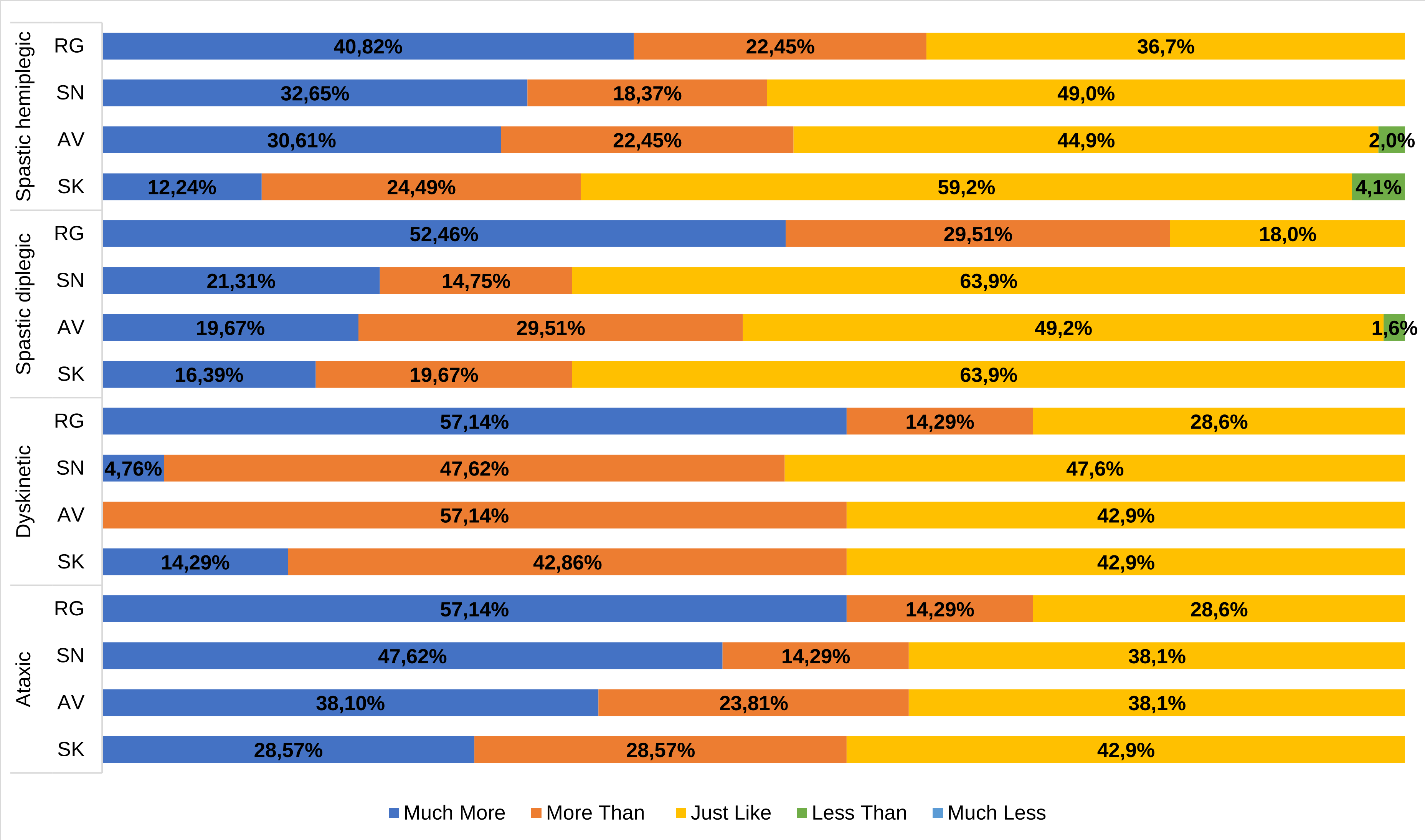
Figure 4.16 Box plot of the registration quadrant in the different subtypes

Figure 4.17 represents the percentage of participants who scored in the different SP2 bands. In general, most of the participants in each subtype scored within the "More" band. The seeking and sensitivity quadrants had a higher percentage of participants scoring in the "Just Like" band in the spastic diplegic subtype. There were also more participants scoring within the norm ("Just Like" band) in the seeking quadrant in the spastic hemiplegic subtype.

When examining each subtype individually, most of the participants in the ataxic subtype scored outside of the norm in all four quadrants. High percentages scored in the "More" band in all four quadrants, with 71.43% in the registration quadrant, 61.90% in the sensitivity and avoiding quadrants, and 57.14% in the seeking quadrant. A similar trend was observed in the dyskinetic subtype; whereby most of the participants scored in the "More" band in all of the quadrants, that is, 71.43% in the registration quadrant, 57.14% in the seeking and the avoidant quadrants, and 52.38% in the sensitivity quadrant. No participants scored in the "Less" bands in either of the subtypes.

In the spastic diplegic subtype, 81.97% of participants scored in the "More" band in the registration quadrant. More participants scored in the "Much More" (52.46%) band than in the "More Than" (29.51%) band. Most (63.93%) of the participants scored in the "Just Like" band in the seeking and sensitivity quadrants. An equal percentage (49.18%) of participants scored in the "More" and "Just Like" bands in the avoiding quadrant; however, 1.64% of participants scored in the "Less" band, indicating that a total of 52.82% of participants fell out of the norm in the avoiding quadrant. In the spastic hemiplegic subtype, the majority of participants scored in the "More" band in the avoiding (53.06%), sensitivity (51.02%), and registration (63.27%) quadrants. More participants scored in the "Just Like" band in the seeking (59.18%) quadrant.

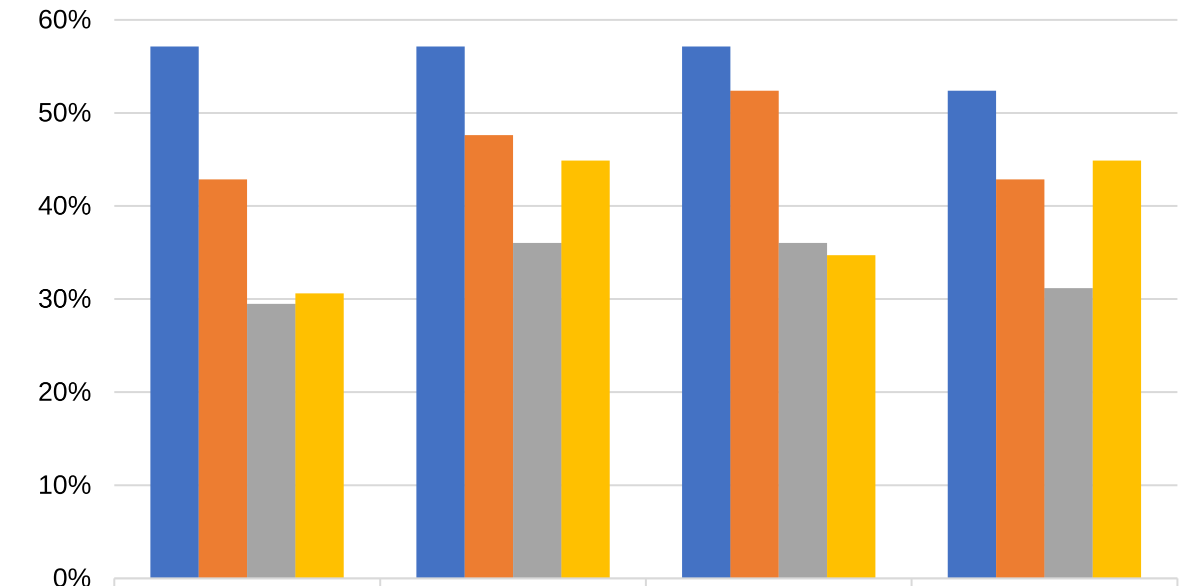
In order to determine the prevalence of SMP in the different subtypes, the percentages of the "More" and "Less" bands were combined. The seeking pattern was most prevalent in the ataxic (57.14%) and dyskinetic (57.14%) subtypes. The sensitivity pattern was most prevalent in the ataxic (61.90%), dyskinetic (52.38%), and hemiplegic (51.02%) subtypes. There was a high prevalence of avoiding and registration patterns in all the subtypes.



SK=seeking; AV= avoiding; SN= sensitivity; RG= registration

Figure 4.17 Distribution of participants in the quadrants in the different subtypes

Figure 4.18 below represents the percentage of participants who were grouped into the four factors in Dunn's Sensory Processing Framework. In order to be classified into one of the factors, the participant had to fall out of the "Just Like" band in both of the contributing quadrants. Those that only fell out in one quadrant were not included.



	Active	Passive	High threshold	Low threshold
A	57,14%	57,14%	57,14%	52,38%
DY	42,86%	47,62%	52,38%	42,86%
SD	29,51%	36,07%	36,07%	31,15%
SH	30,61%	44,90%	34,69%	44,90%

A=Ataxic; DY=Dyskinetic; Spastic diplegic; and SH=Spastic hemiplegic

Figure 4.18 Predominant neurological thresholds and self-regulatory strategies in the different subtypes

The ataxic subtype displayed a high prevalence of both regulatory strategies, with 57.14% of participants scoring in the active and passive factors. The high (57.14%), and low (52.38%) neurological thresholds were also highly prevalent. High neurological thresholds (52.38%) were prevalent in the dyskinetic subtype, with the low threshold only occurring in 42.86% of participants. The passive strategy (47.62%) was more prevalent than the active strategy (42.86%) in the dyskinetic subtype.

The spastic subtypes presented with low percentages, that is, less than 50%, in all four factors. The passive (36.07%) and high thresholds (36.07%) were the most prevalent in the diplegic subtype; whereas the passive (44.90%) and low thresholds

(44.90%) were the most prevalent in the hemiplegic subtype. The hemiplegic subtype had a higher prevalence of the low neurological threshold; in contrast to the other subtypes, where the high neurological threshold was more prevalent.

In order to determine whether there were statistically significant differences between the subtypes the researcher used various statistical measures. The one-way ANOVA test was performed based on the means of the four main subtypes in the four sensory quadrants. The Fisher's exact test used the proportions of participants that scored outside of the norm. These tests (table 4.7) revealed that there were no statistically significant differences between the subtypes in the different quadrants.

Table 4.7 Comparison between mean scores and proportions and level of significance in the quadrants in the different subtypes

		Seeking	Avoiding	Sensitivity	Registration
Ataxic	Mean	43.38	52.48	48.90	59.24
	Sd	16.19	16.86	14.78	18.82
Dyskinetic	Mean	47.52	46.38	41.67	56.33
	Sd	11.27	8.29	8.83	12.68
Spastic diplegic	Mean	45.90	47.36	41.31	58.11
	Sd	16.36	15.59	14.02	15.77
Spastic hemiplegic	Mean	43.14	49.47	44.82	51.67
	Sd	16.81	16.86	15.76	17.02
ANOVA (mean)	p-value	0.545	0.514	0.156	0.153
Fisher's exact (proportion)	p-value	0.201	0.848	0.146	0.167

Lastly, the researcher compared the proportion of participants scoring outside of the norm in each subtype using the z-test of proportions. This test aimed to determine if there were differences between the specific subtypes. Statistically significant differences were revealed between the ataxic and spastic diplegic (p=0.040) subtypes in the sensitivity quadrant. Another significant difference was identified between the spastic diplegic and hemiplegic (p=0.028) subtypes in the registration quadrant.

4.3.5 Sensory modulation in the sensory systems in different types of cerebral palsy

The fifth objective aimed to compare the quality of sensory modulation in the sensory systems in the different CP subtypes.

Figure 4.19 to 4.24 represent the box and whisker plots of the six sensory sections in the different subtype of CP.

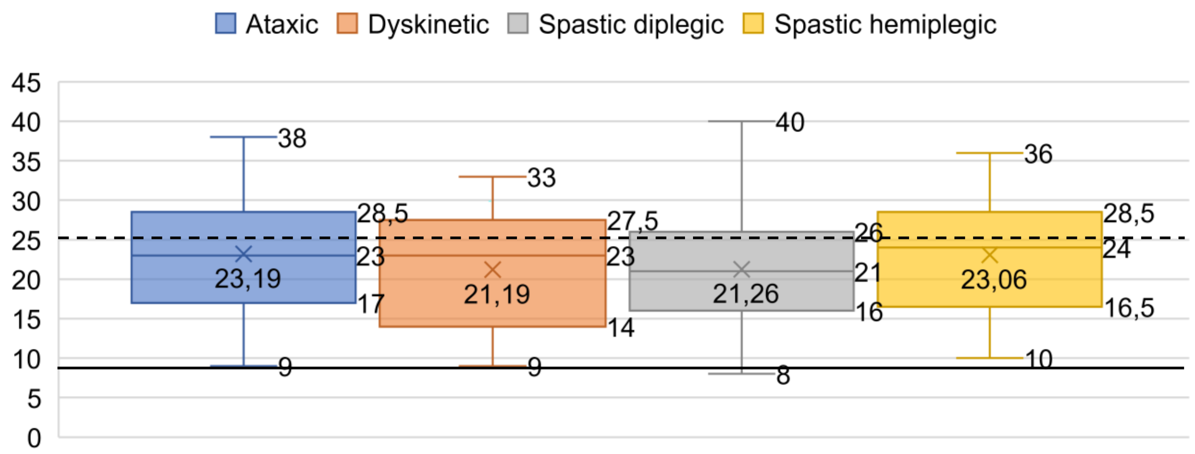


Figure 4.19 Box plot of the auditory processing section in the different subtypes

Figure 4.19 represents the auditory processing scores. The dyskinetic subtype had the largest box; however, the diplegic subtype had the longest tail. The ataxic (23.19) and hemiplegic (23.06) subtypes had the highest means. The diplegic (21.26) and dyskinetic (21.19) subtypes had the lowest means. All the mean scores were below the dashed line, indicating that participants tended to score in the "Just Like" band. A few participants in the diplegic subtype scored below the solid black line ("Less" band).

There were slight differences in the box plots (figure 4.20) in the visual processing section. The ataxic subtype had the largest box, although all four subtypes had equal ranges. The ataxic subtype had the largest mean (17.81). The dyskinetic (15.71) and hemiplegic (15.29) subtypes had similar means. The diplegic subtype had the lowest mean, which was 14.56. All the mean scores were below the dashed line. Some participants scored below the solid black line ("Less" band) in all the subtypes, especially in the hemiplegic subtype.

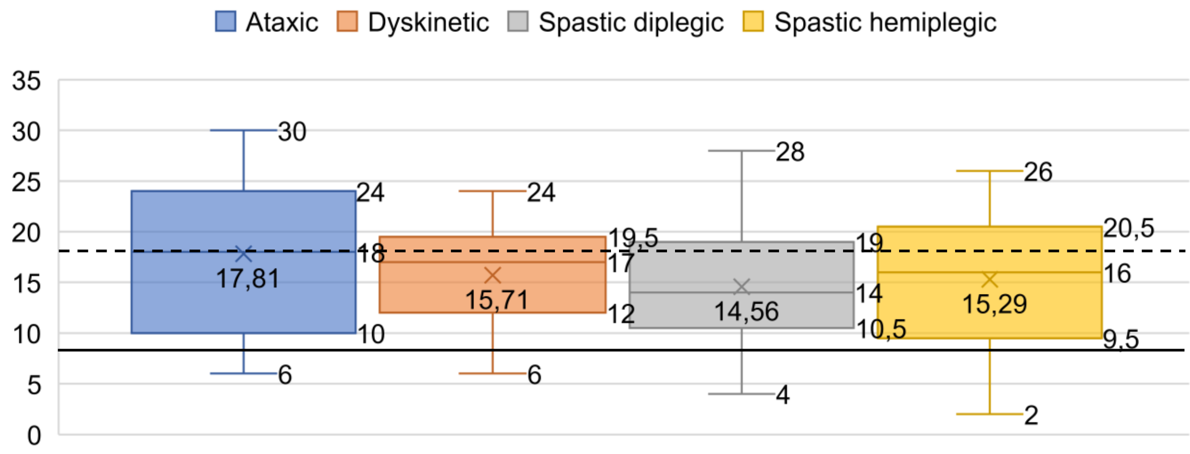


Figure 4.20 Box plot of the visual processing section in the different subtypes

There were some differences in the box plots (figure 4.21) in the touch processing section in the different subtypes. The ataxic subtype had the longest box plot, while the dyskinetic and diplegic subtypes had the smallest box plots. However, the range was the biggest in the hemiplegic subtype due to the longer tail and presence of an outlier. There was also variability in the diplegic subtype, which had three outliers. The ataxic subtype had the largest mean (22.81), followed by the hemiplegic subtype (22.16). The dyskinetic (19.38) and diplegic (21.79) had the lower mean scores. The mean scores in the ataxic and hemiplegic subtypes were above the dashed line, while the diplegic and dyskinetic means were below the line. Some participants scored in the "Less" band in the dyskinetic and hemiplegic subtypes.

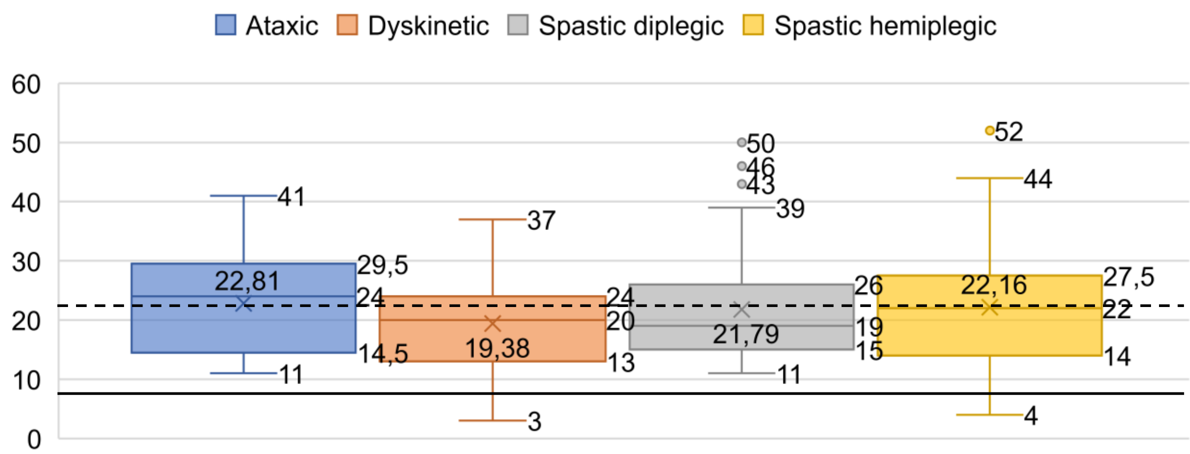


Figure 4.21 Box plot of the touch processing section in the different subtypes

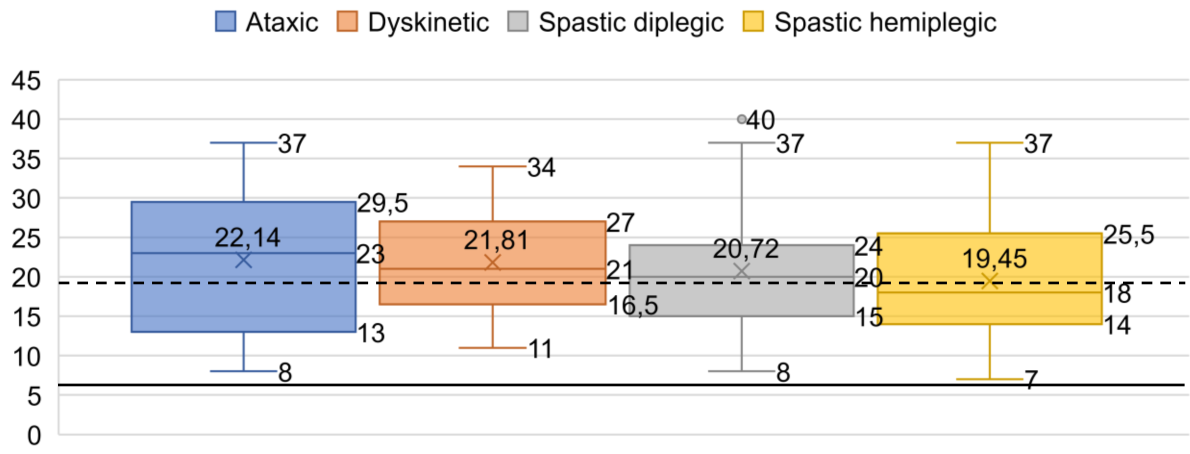


Figure 4.22 Box plot of the movement processing section in the different subtypes

Figure 4.22 represents the box plots for the movement processing section for the different CP subtypes. The ataxic subtype had the largest box plot, as well as the largest mean (22.14). The diplegic subtype had the smallest box plot; however, the range was the longest in this subtype due to the long tail and the outlier. The mean score in the hemiplegic subtype was the lowest (19.45). All the mean scores fell above the dashed line. None of the participants scored below the solid black line.

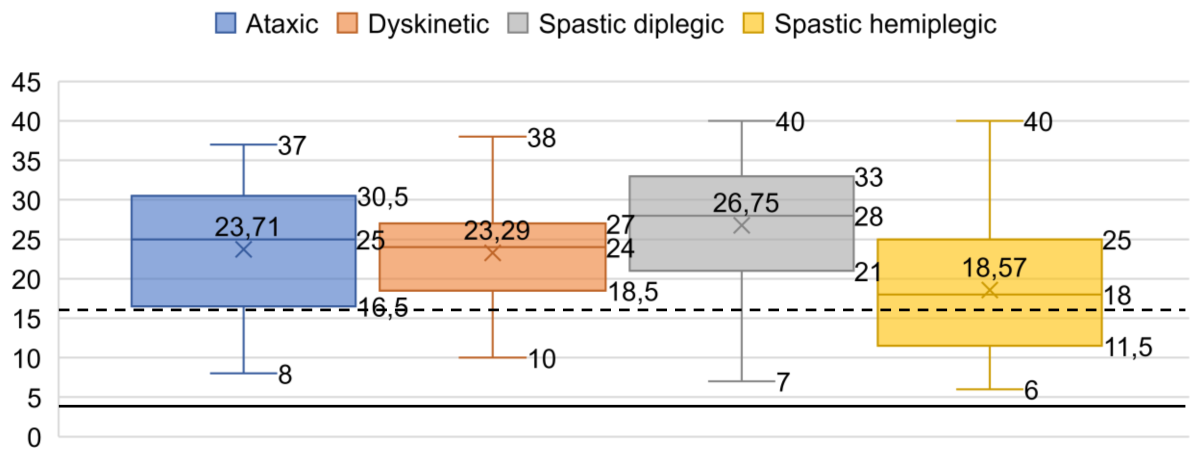


Figure 4.23 Box plot of the body position processing section in the different subtypes

There were some differences in the box plots (figure 4.23) in the body position processing section. The means in the ataxic (23.71) and dyskinetic (23.29) subtypes were similar; however, the box plot in the latter was much smaller. The diplegic subtype (26.75) had the highest mean. The hemiplegic subtype had the lowest mean, which was 18.57. All the mean scores were above the dashed line. None of the participants scored in the “Less” band.

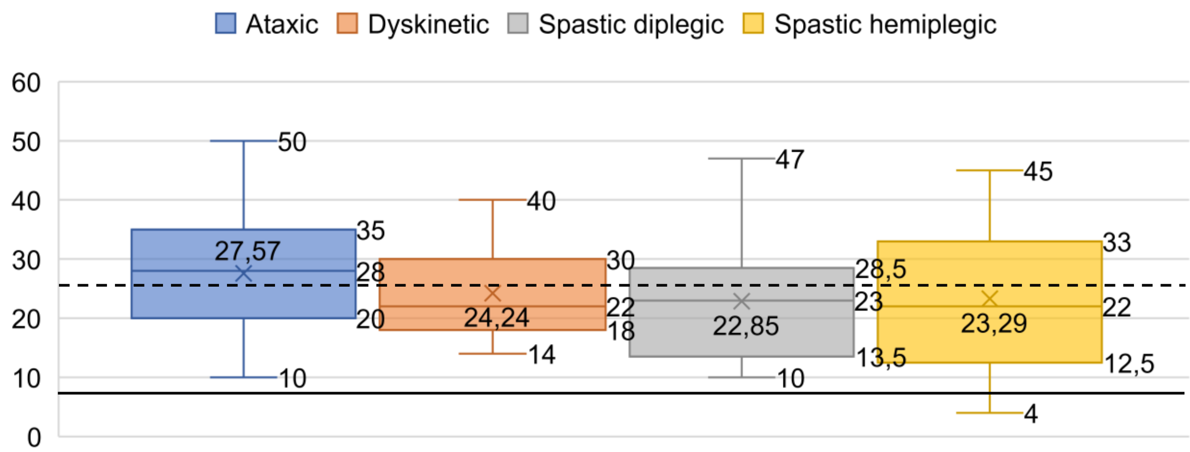
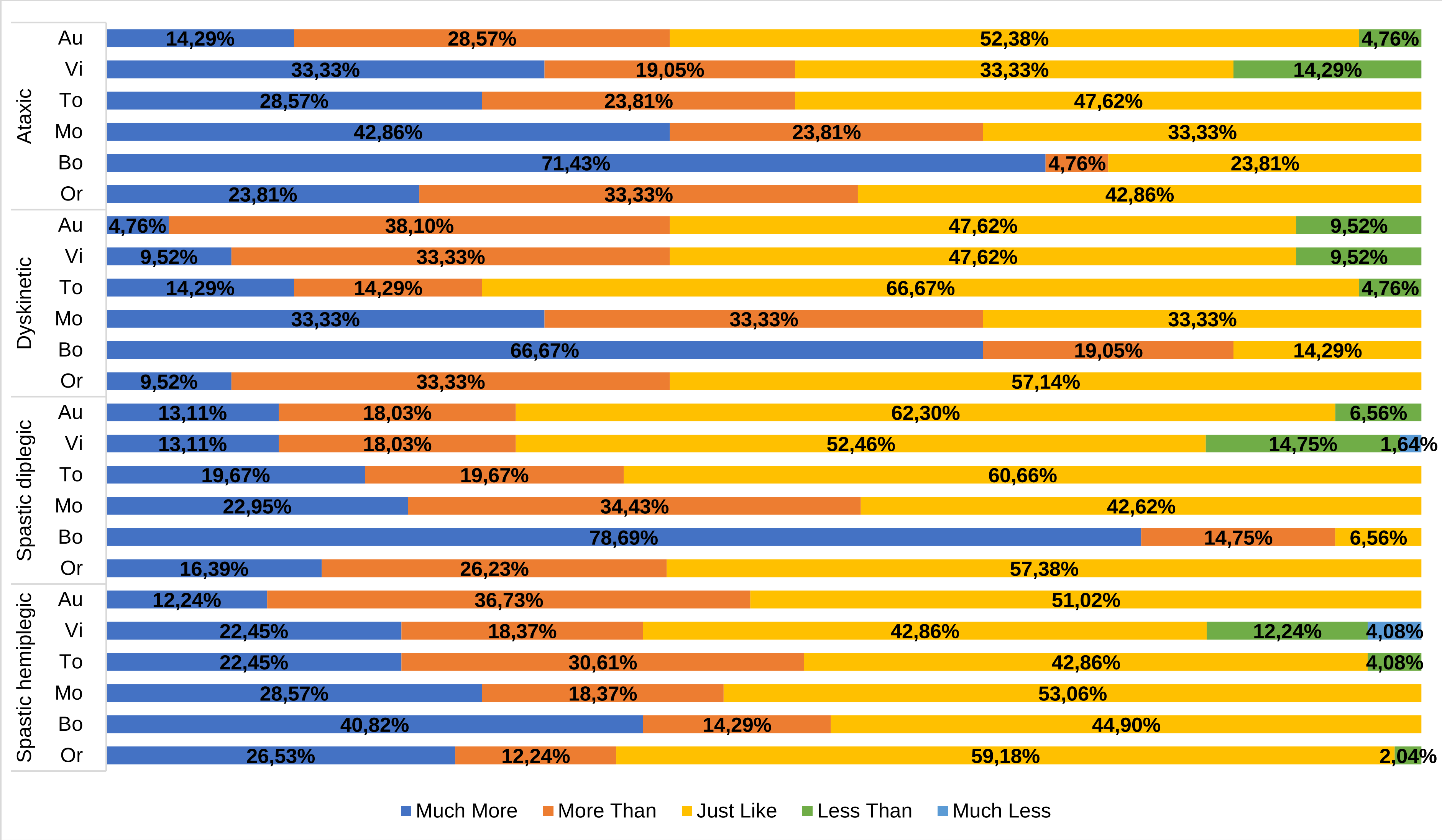


Figure 4.24 Box plot of the oral sensory processing section in the different subtypes

Figure 4.24 represents the box plots for the oral sensory processing section. The ataxic subtype had the largest mean (27.57) and was the only one to fall above the dashed line. The diplegic (22.85) subtype had the smallest mean. A few participants scored below the solid black like (“Less” band) in the hemiplegic subtype.

Figure 4.25 represents the percentage distribution for each sensory section in the different subtypes. The majority of participants in the ataxic subtype scored in the “More” band in five of the six sensory systems, namely the visual (52.38%), touch (52.38%), movement (66.67%), body position (76.19%), and oral sensory (57.14%) systems. In the auditory system, most of the participants (52.38%) scored in the “Just Like” band. Only the movement (66.67%) and body position (85.71%) sections scored in the “More” band in the dyskinetic subtype. Most of the participants scored in the “Just Like” band in the touch (66.67%) and oral sensory (57.14%) systems. Although a higher number of participants scored in the “Just Like” band in the auditory (47.62%) and visual (47.62%) sections, this percentage was less than 50% because 9.52% of participants scored in the “Less Than” band.



Au= auditory processing; Vi= visual processing; To= touch processing; Mo= movement processing; Bo= body position processing; and Or= oral sensory processing

Figure 4.25 Distribution of participants in the sensory systems in the different subtypes

In the spastic diplegic subtype more participants scored in the “Just Like” band in the auditory (62.30%), visual (52.46%), touch (60.66%), and oral sensory (57.38%) systems. Only two sensory systems had the majority of participants scoring in the “More” band, namely the movement (57.38%) and the body position (93.44%) processing sensory systems. Quite a high number (16.39%) of participants scored in the “Less” band in the visual system.

In the spastic hemiplegic subtype, there were more participants scoring in the “Just Like” band in the auditory (51.02%), movement (53.06%), and oral sensory (59.18%) systems. Although the majority of participants (42.86%) scored in the “Just Like” band in the visual system, 16.33% scored in the “Less” band; thereby indicating that more participants had visual difficulties. The touch (53.06%) and body position (55.10%) processing systems had more participants scoring in the “More” band.

When combining the “More” and “Less” scores, auditory processing difficulties were only observed in the dyskinetic (52.38%) subtype. Visual processing difficulties were prevalent in the ataxic (66.67%), dyskinetic (52.38%), and spastic hemiplegic (57.14%) subtypes. Only the ataxic (52.38%) and hemiplegic (57.14%) subtypes presented with touch processing difficulties. Movement processing difficulties were observed in all the subtypes, except for the hemiplegic subtype. All the subtypes presented with body position processing difficulties. Only the ataxic (57.14%) subtype presented with oral sensory processing difficulties.

In order to determine whether there were statistically significant differences between the subtypes, the researcher used the Kruskal-Wallis test (based on the mean total raw scores) and the Fisher’s exact test (based on the proportion of participants that scored out of the norm). The p-values are displayed in table 4.8. The majority of the sensory systems had statistically insignificant p-values between the subtypes in both tests. However, a statistically significant difference was found between the means in the body position processing ($p=0.000$) section between the four main CP subtypes. Furthermore, the proportions ($p=0.000$) were also found to be statistically significant.

The z-test was done to compare the subtypes individually, based on the proportions of participants scoring outside of the norm. The z-test revealed statistically significant differences between the dyskinetic and hemiplegic (p=0.015) subtypes, as well as between the diplegic and hemiplegic (p=0.000) subtypes in the body position processing section. Therefore, providing strong evidence that body position processing is different in different CP subtypes.

Table 4.8 Comparison between mean scores and proportions and level of significance in the sensory sections

		Au	**Vi**	**To**	**Mo**	**Bo**	**Or**
Ataxic	Mean	23.19	17.81	22.81	22.14	23.71	27.57
	SD	7.91	7.97	9.06	9.06	8.63	10.52
Dyskinetic	Mean	21.19	15.71	19.38	21.81	23.29	24.24
	SD	7.20	4.76	8.15	6.80	6.99	7.50
Spastic diplegic	Mean	21.26	14.56	21.79	20.72	26.75	22.85
	SD	7.57	5.64	9.66	8.07	7.97	10.19
Spastic hemiplegic	Mean	23.06	15.29	22.16	19.45	18.57	23.29
	SD	6.98	6.38	9.93	7.52	8.39	11.42
Kruskal-Wallis (mean)	p-value	0.428	0.368	0.676	0.441	**0.000**	0.286
Fisher's exact (proportion)	p-value	0.531	0.472	0.160	0.322	**0.000**	0.650

Au= auditory processing; Vi= visual processing; To= touch processing; Mo=movement processing; Bo=body position processing

The Kruskal-Wallis test was used to compare each question in the different subtypes. Eight statistically significant differences were identified in the questions pertaining to the sensory sections (question 1-52) between the CP subtypes. These differences occurred in question 12, "*needs help to find objects that are obvious to others"* (p=0.017) from the visual section; and question 33, "*loses balance unexpectantly when walking on an uneven surface"* (p=0.020) from the movement section. Furthermore, differences were found in question 35, "*moves stiffly"* (p=0.000); question 36, "*becomes tired easily, especially when standing or holding the body in position"* (p=0.002); question 37, "*seems to have weak muscles"* (p=0.043); question 38, "*props to support self (for example, hold head in hands, leans against wall)"* (p=0.000); question 39, "*clings to objects, walls, or banisters more than same-aged children"* (p=0.000); and question 41, “*drapes self over furniture or on other people”* (p=0.000) from the body position processing section.

Thirteen significant differences occurred between the questions in the spastic diplegic and spastic hemiplegic subtypes. The differences were identified in question five, *“becomes unproductive with background noise (for example, fan, refrigerator)”* (p=0.012) and question seven, *“seems not to hear when I call his or her name (even though hearing is OK)”* (p=0.049) from the auditory section; question 12, “*needs help to find objects that are obvious to others”* from the visual section (p=0.016); question 24, *“seems unaware of temperature changes”* (p=0.042) from the touch section; and question 33, “*loses balance unexpectantly when walking on an uneven surface”* (p=0.012) from the movement section. Question 35, “*moves stiffly”* (p=0.000); question 36, “*becomes tired easily, especially when standing or holding the body in position”* (p=0.000); question 37, “*seems to have weak muscles”* (p=0.012); question 38, “*props to support self (for example, hold head in hands, leans against wall)”* (p=0.000); question 39, “*clings to objects, walls, or banisters more than same-aged children”* (p=0.000); question 40, *“walks loudly as if feet are heavy”* (p=0.030); and question 41, “*drapes self over furniture or on other people”* (p=0.000) were also identified as being statistically significant from the body position section.

4.3.6 Behavioural responses associated with sensory modulation in different types of cerebral palsy

Objective six compared the behavioural sections in the different subtypes.

The box and whisker plots of the behavioural sections are shown below.

There were slight differences between the distributions in the conduct section (figure 4.26). The dyskinetic subtype (21.76) had the highest mean, followed by the ataxic subtype (20.52). The diplegic (19.92) and hemiplegic (19.53) subtypes had the lowest mean scores. There was one outlier in the diplegic subtype. All the mean scores were below the dashed line. Some participants fell below the solid black line (“Less” band) in the ataxic, spastic diplegic, and spastic hemiplegic subtypes.

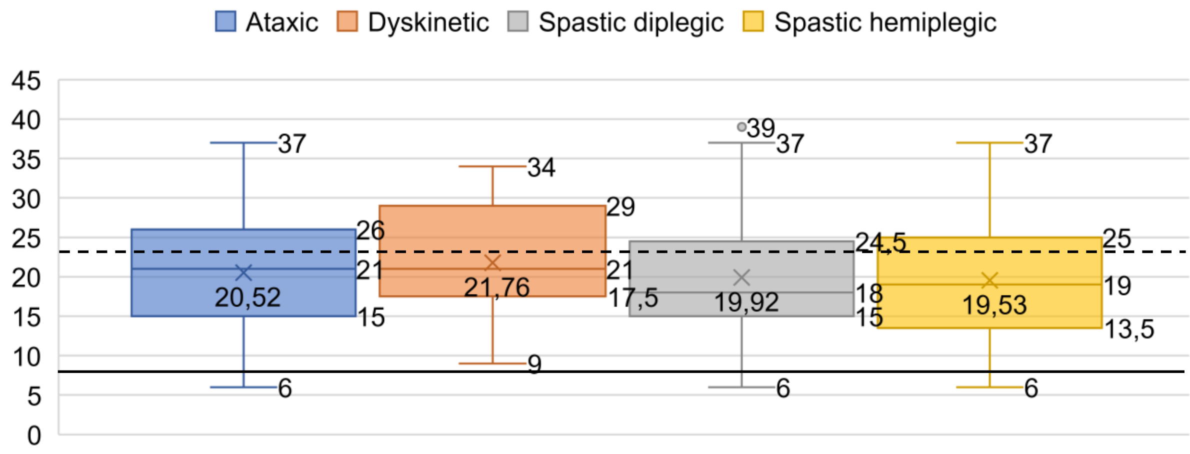


Figure 4.26 Box plot of the conduct section in the different subtypes

Figure 4.27 represents the box plots for the social-emotional section for the different CP subtypes. The ataxic subtype had the largest mean (37.76), followed by the hemiplegic (35.14) subtype. The diplegic (34.26) and dyskinetic (32.61) had the lowest mean scores. All of the mean scores fell above the dashed line. Some participants scored below the solid black line in the spastic hemiplegic subtype.

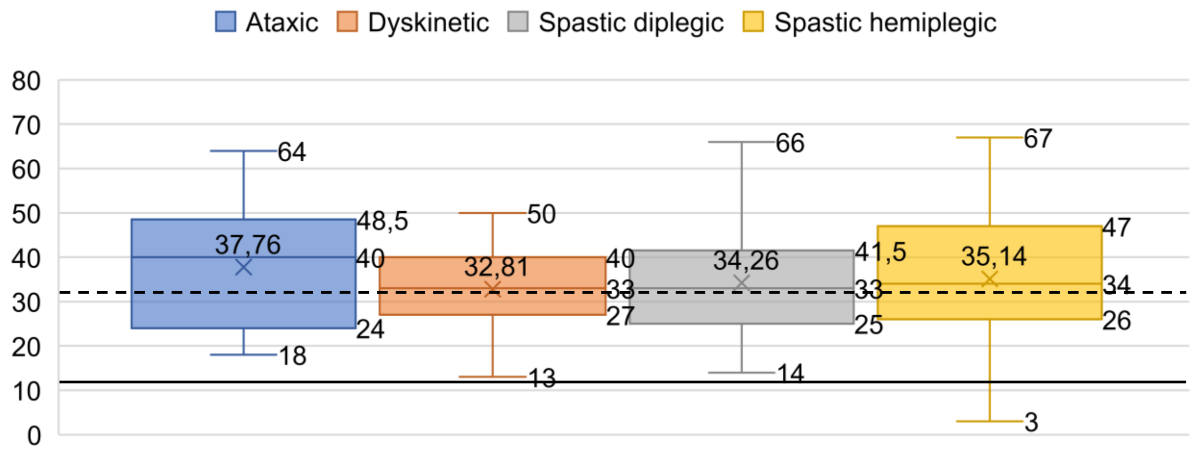


Figure 4.27 Box plot of the social-emotional section in the different subtypes

Figure 4.28 represents the box plots for the attentional section. The ataxic subtype had the largest mean (25.43) and was the only one to fall above the dashed line. The diplegic (22.69) subtype had the smallest mean. There was one outlier in the diplegic subtype. None of the participants scored below the solid black line ("Less" band).

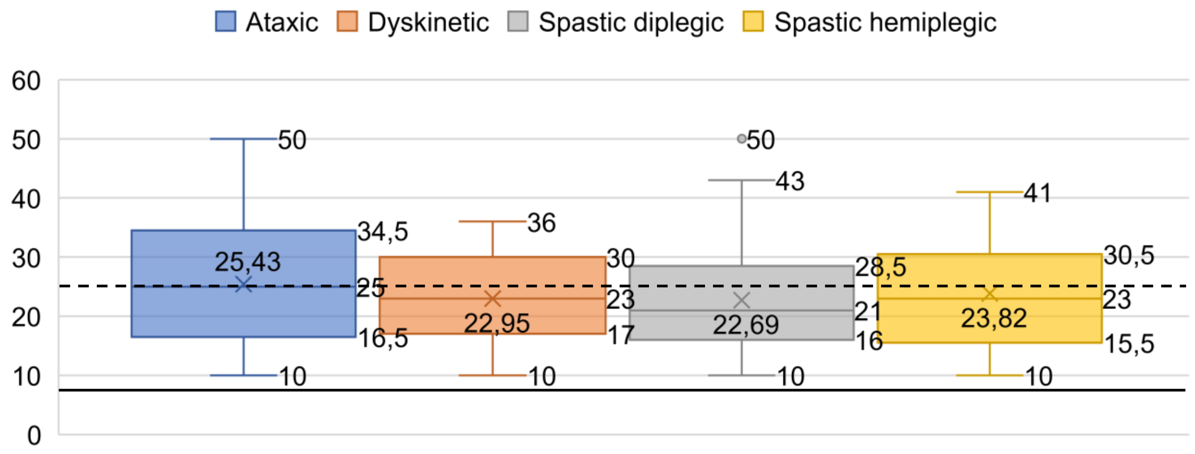
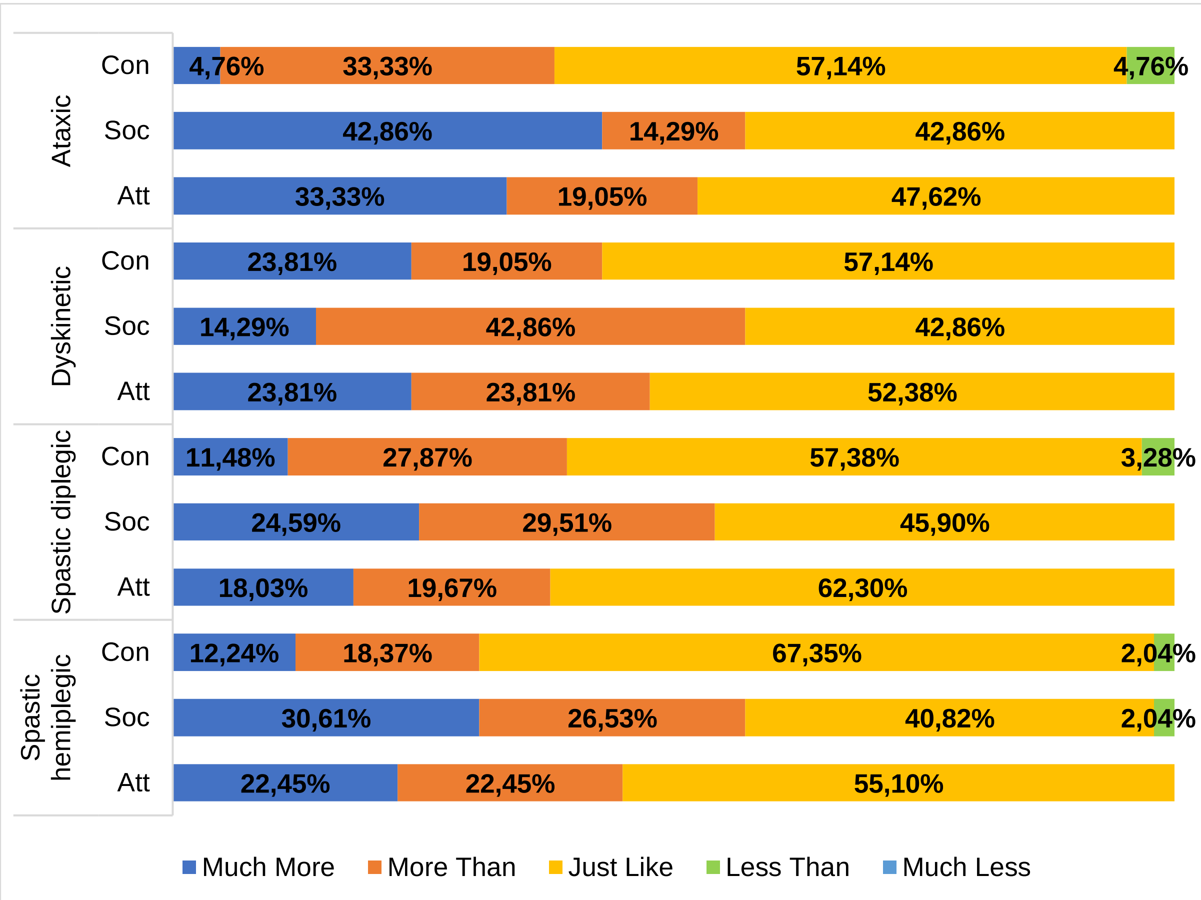


Figure 4.28 Box plot of the attentional section in the different subtypes

Figure 4.29 portrays the proportion of participants scoring in the different behavioural sections.



Con=conduct; Soc= social-emotional; and Att= attentional

Figure 4.29 Distribution of participants in the behavioural systems in the different subtypes

The majority of participants in the ataxic group scored within the “More” band in the social-emotional (57.14%) and attentional sections (52.38%). In the conduct section, most of the participants (57.14%) scored within the “Just Like” band.

In the dyskinetic group, the majority of the participants (57.14%) scored in the “More” band in the social-emotional section. More than half of the participants scored in the “Just Like” band in the conduct (57.14%) and the attentional (52.38%) sections, indicating that the majority did not struggle with these areas.

A similar trend was also seen in the diplegic and hemiplegic subtypes; whereby most of the participants fell out of the norm in the social-emotional sections (SD=54.10%; (SH=59.18%), but not in the attentional and conduct sections. The spastic diplegic subtype had 57.38%, and the hemiplegic subtype had 67.35% of the participants scoring in the “Just Like” band in the conduct section. Within the attentional section, 62.30% of the diplegic subtype and 55.10% of the hemiplegic subtype scored within with the norm.

The sum of the “More” and “Less” bands revealed very few behavioural difficulties in the CP subtypes. The social-emotional was found to be prevalent in all the subtypes. Additionally, 52.38% of the ataxic participants presented with attentional difficulties.

In order to determine whether there were statistically significant differences between the subtypes in the behavioural sections, the researcher used the Kruskal-Wallis test (mean raw scores), the Fisher’s exact test (proportion of participants scoring outside of the norm), as well as the z-test of proportions. These tests revealed no significant differences in the behavioural sections between the means and the proportions in the four CP subtypes (table 4.9). There were also no proportional differences identified in the z-testing between the different subtypes. Therefore, none of the statistical measures revealed significant differences between the different subtypes in the behavioural sections.

The questions in the behavioural sections (question 53-86) were also compared to determine whether differences occurred between the subtypes. Question 77, *“struggles to pay attention”* from the attentional section was found to be statistically significant between the four CP subtypes (p=0.037), as well as between the diplegic and hemiplegic subtypes (p=0.012).

Table 4.9 Comparison between mean scores and proportions and level of significance in the behavioural sections

		Conduct	Social-emotional	Attentional
Ataxia	Mean	20.52	37.76	25.43
	Sd	7.29	14.26	11.20
Dyskinesia	Mean	21.76	32.81	22.95
	Sd	7.22	8.52	8.00
Spastic diplegia	Mean	19.92	34.26	22.69
	Sd	7.60	11.92	9.36
Spastic hemiplegia	Mean	19.53	35.14	23.82
	Sd	7.35	13.63	8.57
Kruskal-Wallis (mean)	p-value	0.591	0.773	0.760
Fisher's exact (proportion)	p-value	0.695	0.970	0.641

Section 4.4 will examine the other results which are pertinent to the study.

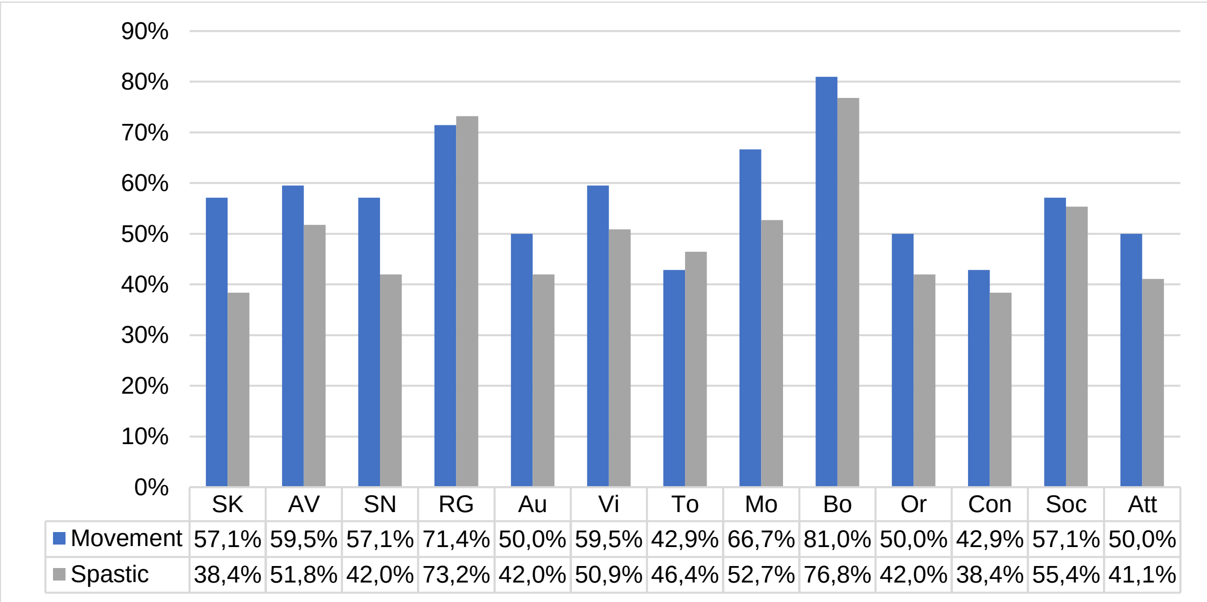
4.4 OTHER FINDINGS INFLUENCING SENSORY MODULATION IN CHILDREN WITH CEREBRAL PALSY

The following section discusses the results pertaining to the following categories: movement versus the spastic disorders, GMFCS levels, age, gender, duration of gestation, and birth weight. The graphs (figures 4.30-4.35) represent the sum of the "More" and "Less" bands. Table 4.10 portrays the p-values of all the categories.

4.4.1 Movement disorders versus spastic disorders

Figure 4.30 represents the comparison between the movement disorders and the spastic disorders. The movement disorder participants presented with seeking (57.14%), avoiding (59.52%), sensitivity (57.14%), and registration (71.43%) sensory modulation patterns. They also had difficulties with auditory (50.00%), visual (59.52%), movement (66.67%), body position (80.95%), and oral sensory (50.00%) processing, as well as social-emotional (57.14%) and attentional (50.00%) problems. Therefore, the movement disorder participants had difficulty in 11 out of the 13 sections.

The spastic disorder participants presented with avoiding (51.79%) and registration (73.21%) sensory modulation patterns. They also had difficulties with visual (50.89%), movement (52.68%), and body position (76.79%) processing, as well as social-emotional (55.36%) problems. Therefore, the spastic disorder participants had difficulties in six out of the thirteen sections.



	SK	AV	SN	RG	Au	Vi	To	Mo	Bo	Or	Con	Soc	Att
Movement	57,1%	59,5%	57,1%	71,4%	50,0%	59,5%	42,9%	66,7%	81,0%	50,0%	42,9%	57,1%	50,0%
Spastic	38,4%	51,8%	42,0%	73,2%	42,0%	50,9%	46,4%	52,7%	76,8%	42,0%	38,4%	55,4%	41,1%

SK= seeking; AV= avoiding; SN= sensitivity; RG= registration; Au= auditory processing; Vi= visual processing; To= touch processing; Mo=movement processing; Bo=body position processing; Con=conduct; Soc= social-emotional; Att= attentional

Figure 4.30 Comparison between the movement disorder and spastic groups

There were no statistically significant differences between the mean scores (t-test) in the two groups (table 4.10). However, the Fisher's exact test revealed a statistically significant difference (p=0.045) between the proportions of participants scoring outside of the norm in the seeking quadrant. Furthermore, the Kruskal-Wallis test found two statistically significant differences in the questions between the groups, namely question nine, *"prefers to play or work in low lighting"* (p=0.010) and question 76, *"misses eye contact with me during everyday interactions"* (p=0.022).

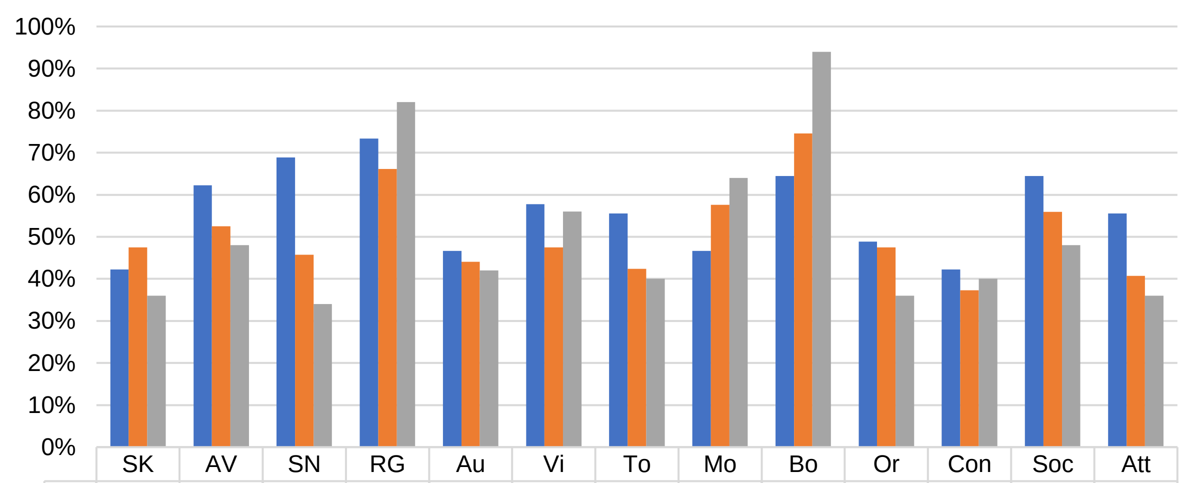
Table 4.10. Fisher's exact p-values for the movement versus spastic disorders, GMFCS levels, age, gender, gestation, and birth weight groups

	Movement vs spastic disorders		**GMFCS**		**Age**		**Gender**		**Gestation**		**Birth weight**	
	T-test	Fisher's exact	ANOVA	Fisher's exact	T-test	Fisher's exact	T-test	Fisher's exact	T-test	Fisher's exact	T-test	Fisher's exact
SK	0.212	**0.045**	0.716	0.418	**0.038**	0.193	0.895	0.617	0.840	0.714	0.577	0.847
AV	0.595	0.469	0.383	0.367	0.579	0.518	0.565	0.714	0.784	0.856	0.372	0.330
SN	0.282	0.105	0.113	**0.041**	0.087	0.254	0.823	1.000	0.513	0.466	0.332	0.565
RG	0.353	0.841	0.487	0.162	0.250	0.203	0.762	0.581	0.769	**0.023**	0.968	0.506
	T-test	Fisher's exact	Kruskal-Wallis	Fisher's exact	T-test	Fisher's exact	T-test	Fisher's exact	T-test	Fisher's exact	T-test	Fisher's exact
Au	0.837	0.466	0.723	0.901	0.085	0.871	0.110	0.318	0.387	0.636	0.915	0.444
Vi	0.114	0.369	0.816	0.536	0.226	0.193	0.372	0.513	0.862	0.586	0.671	0.440
To	0.652	0.720	0.317	0.273	0.256	0.744	0.163	0.869	0.546	0.718	0.608	0.847
Mo	0.178	0.145	0.647	0.231	0.078	0.252	0.343	1.000	0.710	1.000	0.454	0.698
Bo	0.762	0.666	**0.001**	**0.001**	0.473	1.000	0.814	1.000	0.544	0.182	0.735	0.246
Or	0.113	0.466	0.264	0.369	0.186	0.256	0.103	0.250	0.596	0.585	0.550	0.252
Con	0.280	0.712	0.230	0.875	0.203	0.870	0.404	0.866	0.760	**0.003**	0.741	0.438
Soc	0.699	0.858	0.146	0.281	0.907	0.418	0.633	1.000	0.750	0.585	0.550	0.556
Att	0.561	0.364	0.166	0.143	**0.056**	0.193	0.688	0.868	0.645	0.464	0.269	0.438

SK= seeking; AV= avoiding; SN= sensitivity; RG= registration; Au= auditory processing; Vi= visual processing; To= touch processing; Mo=movement processing; Bo=body position processing; Con=conduct; Soc= social-emotional; Att= attentional

4.4.2 GMFCS levels

The GMFCS level I (n=45), II (n=59), and III (n=50) groups were relatively evenly distributed with regards to the number of participants in each group. The GMFCS level I group was made up of five participants with ataxia, six participants with dyskinesia, one participant with spastic diplegia, 33 participants with spastic hemiplegia, and no participants with spastic quadriplegia. The GMFCS level II group was made up of 13 participants with ataxia, eight participants with dyskinesia, 21 participants with spastic diplegia, 16 participants with spastic hemiplegia, and one participant with spastic quadriplegia. The GMFCS level III group was made up of three participants with ataxia, seven participants with dyskinesia, 39 participants with spastic diplegia, and one participant with spastic quadriplegia.



	SK	AV	SN	RG	Au	Vi	To	Mo	Bo	Or	Con	Soc	Att
I	42,2%	62,2%	68,9%	73,3%	46,7%	57,8%	55,6%	46,7%	64,4%	48,9%	42,2%	64,4%	55,6%
II	47,5%	52,5%	45,8%	66,1%	44,1%	47,5%	42,4%	57,6%	74,6%	47,5%	37,3%	55,9%	40,7%
III	36,0%	48,0%	34,0%	82,0%	42,0%	56,0%	40,0%	64,0%	94,0%	36,0%	40,0%	48,0%	36,0%

SK= seeking; AV= avoiding; SN= sensitivity; RG= registration; Au= auditory processing; Vi= visual processing; To= touch processing; Mo=movement processing; Bo=body position processing; Con=conduct; Soc= social-emotional; Att= attentional

Figure 4.31 Comparison between GMFCS level I, II, and III

Figure 4.31 examines the prevalence of SMD between the three different GMFCS levels. The GMFCS level I participants presented with avoiding (62.22%), sensitivity (68.89%), and registration (73.33%) patterns. They also presented with visual (57.78%), touch (55.56%), and body position (64.44%) processing difficulties, as well as social-emotional (64.44%) and attentional problems (55.56%). Therefore, eight of the 13 sections were problematic for the GMFCS level I participants.

The GMFCS level II participants presented with avoiding (52.54%) and registration (66.10%) patterns. They also had difficulties with movement (57.63%) and body position (74.58%) processing, as well as social-emotional (55.93%) difficulties. Therefore, the GMFCS level II participants had difficulties in five out of the 13 sections.

The GMFCS level III participants only presented with registration (82.00%) patterns in the quadrants. Within the sensory systems, they presented with visual (56.00%), movement (64.00%) and body position (94.00%) processing difficulties. They had no behavioural problems. Therefore, four out of the 13 sections were areas of concern for the GMFCS level III participants.

There were no statistically significant differences identified between the mean scores in the quadrants or the behavioural sections between the different GMFCS levels. However, there was a statistically significant difference between the mean scores in the body position processing section (p=0.001). Furthermore, the Fisher's exact test indicated that there were statistically significant differences between the proportions in the sensitivity quadrant (p=0.041) and the body position processing section (p=0.001) between the three GMFCS levels.

Z-testing was done to determine whether there were specific differences between the different levels. This test revealed differences in the sensitivity quadrant between level I and II (p=0.019), as well as between GMFCS level I and III (p=0.000). Furthermore, significant differences were identified between GMFCS level III and I (p=0.000) participants, and between the GMFCS level III and II (p=0.007) participants in the body position processing section.

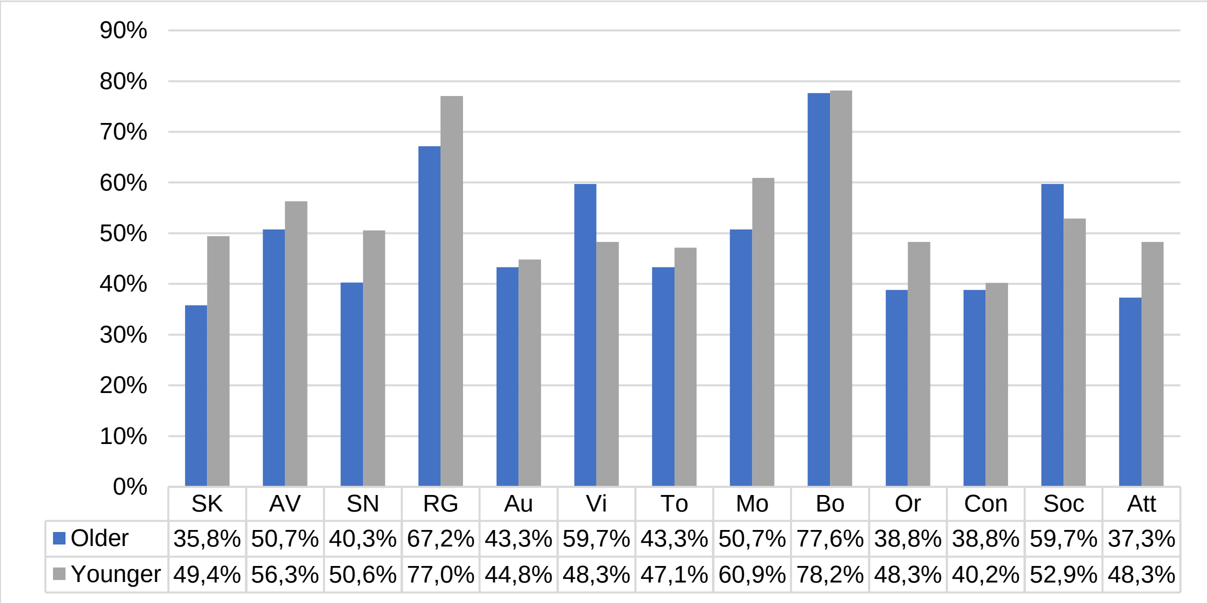
In addition, the questions were analysed individually using the Kruskal-Wallis test to examine whether there were differences between the three levels. Significant p-values were found in 16 of the 86 questions, namely, question one, "*reacts strongly to unexpected or loud noises (for example, sirens, dog barking, hair dryer)"* (p=0.052) from the auditory section; question 12, *"needs help to find objects that are obvious to others"* (p=0.032) from the visual section; question 18, *"shows an emotional or aggressive response to being touched"* (p=0.055) and question 19, *"becomes anxious when standing close to others (for example, in a line)"* (p=0.0014) from the touch section; question 34, *“bumps into things, failing to notice objects or people in the way”* (p=0.054) from the movement section; question 35, “*moves stiffly”* (0.006); question 36, “*becomes tired easily, especially when standing or holding the body in position”* (p=0.027); question 38, “*props to support self (for example, hold head in hands, leans against wall)”* (p=0.000); question 39, “*clings to objects, walls, or banisters more than same-aged children”* (p=0.000); and question 41, “*drapes self over furniture or on other people”* (p=0.002) from the body position section. There was one question from the oral sensory section, that is, question 52, *“bites tongue or lips more than same-aged children”* (p=0.042). There were five questions from the behavioural sections, namely, question 54, *“rushes through colouring, writing, or drawing”* (p=0.017) and question 59, *“has temper tantrums”* (p=0.017) from the conduct section; question 66, *“expresses feeling like a failure”* (p=0.0569) from the social emotional section; as well as question 77, *“struggles to pay attention”* (p=0.004) and question 85, *“has a hard time finding objects in competing backgrounds (for example, shoes in a messy room, pencil in “junk drawer”)”* (p=0.053) from the attentional section.

4.4.3 Age

The younger (5.00 to 9.11 years) children (56.49%) outnumbered the older (10.00 to 14.11 years) children (43.50%) in the sample. The younger group was made up of 12 participants with ataxia, 12 participants with dyskinesia, 33 participants with spastic diplegia, 29 participants with spastic hemiplegia, and one participant with spastic quadriplegia. The older group was made up of nine participants with ataxia, nine participants with dyskinesia, 28 participants with spastic diplegia, 20 participants with spastic hemiplegia, and one participant with spastic quadriplegia. These two groups were fairly homogenous.

The figure below (figure 4.32) compares the scores between the two age bands in the study. The younger participants presented with avoiding (56.32%), sensitivity (50.57%), and registration (77.01%) sensory modulation patterns. Within the sensory systems they presented with movement (60.92%) and body position (78.16%) processing difficulties. They also presented with social-emotional (52.87%) problems. Therefore, six out of the 13 sections were problematic for the younger participants.

The older participants presented with avoiding (50.75%) and registration (67.16%) patterns, together with visual (59.70%), movement (50.75%), and body position (77.61%) processing difficulties. They also had social-emotional (59.70%) problems. Therefore, the older participants had difficulties in six out of the 13 sections.



	SK	AV	SN	RG	Au	Vi	To	Mo	Bo	Or	Con	Soc	Att
Older	35,8%	50,7%	40,3%	67,2%	43,3%	59,7%	43,3%	50,7%	77,6%	38,8%	38,8%	59,7%	37,3%
Younger	49,4%	56,3%	50,6%	77,0%	44,8%	48,3%	47,1%	60,9%	78,2%	48,3%	40,2%	52,9%	48,3%

SK= seeking; AV= avoiding; SN= sensitivity; RG= registration; Au= auditory processing; Vi= visual processing; To= touch processing; Mo=movement processing; Bo=body position processing; Con=conduct; Soc= social-emotional; Att= attentional

4.32 Comparison between age groups, younger (5.00 to 14.11 years) and older (10.00 to 14.11 years)

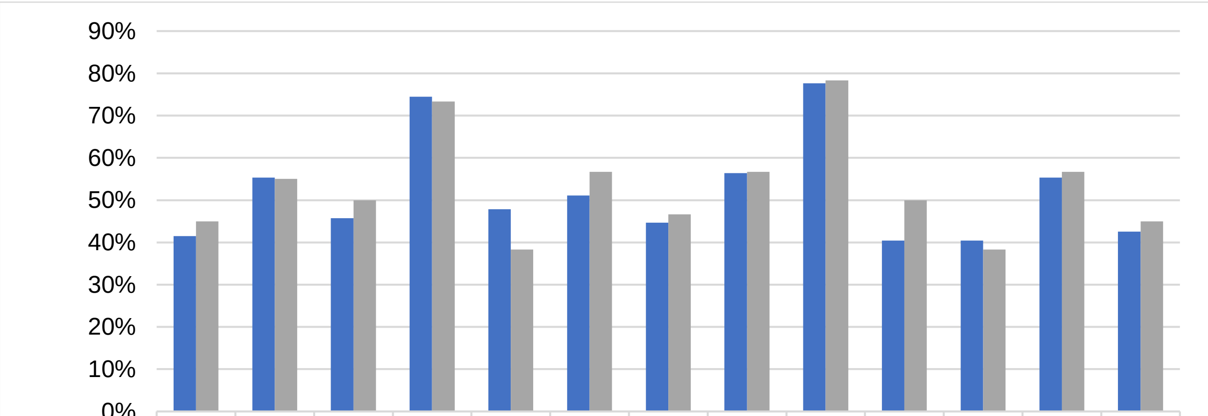
The t-test (table 4.10) revealed significant differences between the mean score of the two age bands in the seeking (p=0.038) quadrant, as well as in the attentional section (p=0.056). No proportional differences were identified between the two age bands.

Twelve differences occurred in the questions between the age bands, that is, in question 14, *“watches people as they move around the room”* (p=0.047) from the visual section; question 16, *shows distress during grooming (for example, fights or cries during haircutting, face washing, fingernail cutting)”* (p=0.041); question 22, *“displays need to touch toys, surfaces, or textures (for example, wants to get the feeling of everything)”* (p=0.055), and question 26, *“seems oblivious to messy hands or face”* (p=0.031) from the touch section; question 33; *“loses balance unexpectedly when walking on an uneven surface”* (p=0.005) from the movement section; question

41, *“drapes self over furniture or on other people”* (p=0.056) from the body position section; and question 49, *“shows a strong preference for certain tastes”* (p=0.0.009) from the oral sensory section. Five differences were identified between the age bands in the behavioural sections, namely, in question 56, *“seems more active than same aged children”* (p=0.021) from the conduct section; question 68, *‘has strong emotional outbursts when unable to complete a task”* (p=0.021); question 77, *“struggles to pay attention”* (p=0.002); question 78, *“looks away from tasks to notice all actions in the room”* (p=0.000); and question 83, *“jumps from one thing to another so that it interferes with activities”* (p=0.027) from the attentional section.

4.4.4 Gender

The study also examined the gender differences (figure 4.33). The male group was made up of 11 participants with ataxia, 18 participants with dyskinesia, 35 participants with spastic diplegia, 29 participants with spastic hemiplegia, and one participant with spastic quadriplegia. The female group was made up of 10 participants with ataxia, three participants with dyskinesia, 26 participants with spastic diplegia, 20 participants with spastic hemiplegia, and one participant with spastic quadriplegia. These groups were somewhat similar, except for the smaller number of female participants with dyskinetic CP.



	SK	AV	SN	RG	Au	Vi	To	Mo	Bo	Or	Con	Soc	Att
Male	41,5%	55,3%	45,7%	74,5%	47,9%	51,1%	44,7%	56,4%	77,7%	40,4%	40,4%	55,3%	42,6%
Female	45,0%	55,0%	50,0%	73,3%	38,3%	56,7%	46,7%	56,7%	78,3%	50,0%	38,3%	56,7%	45,0%

SK= seeking; AV= avoiding; SN= sensitivity; RG= registration; Au= auditory processing; Vi= visual processing; To= touch processing; Mo=movement processing; Bo=body position processing; Con=conduct; Soc= social-emotional; Att= attentional

Figure 4.33 Comparison between males and females

The male participants presented with avoiding (55.32%) and registration (74.47%) patterns. They also had difficulties with visual (51.06%), movement (56.38%), and body position (77.66%) processing. More than half of the participants (55.32%) had social-emotional problems. Therefore, the male participants had problems in six out of the 13 sections.

The female participants presented with avoiding (55.00%), sensitivity (50.00%), and registration (73.33%) patterns, together with visual (56.67%), movement (56.67%), body position (78.33%), and oral sensory (50.00%) processing difficulties. They also had social-emotional (56.67%) problems. Therefore, the female participants presented with difficulties in eight out of the 13 sections.

Statistical analysis did not reveal any differences between the gender groups in the quadrants, sensory or behavioural sections. However, three differences were reported between the genders in the questions, namely question 3, *"struggles to complete tasks when music or TV is on"* (p=0.038) and question 4, *"is distracted when there is a lot of noise around"* (p=0.022) from the auditory section; as well as question 83, *"jumps from one thing to another so that it interferes with activities"* (p=0.029) from the attentional section.

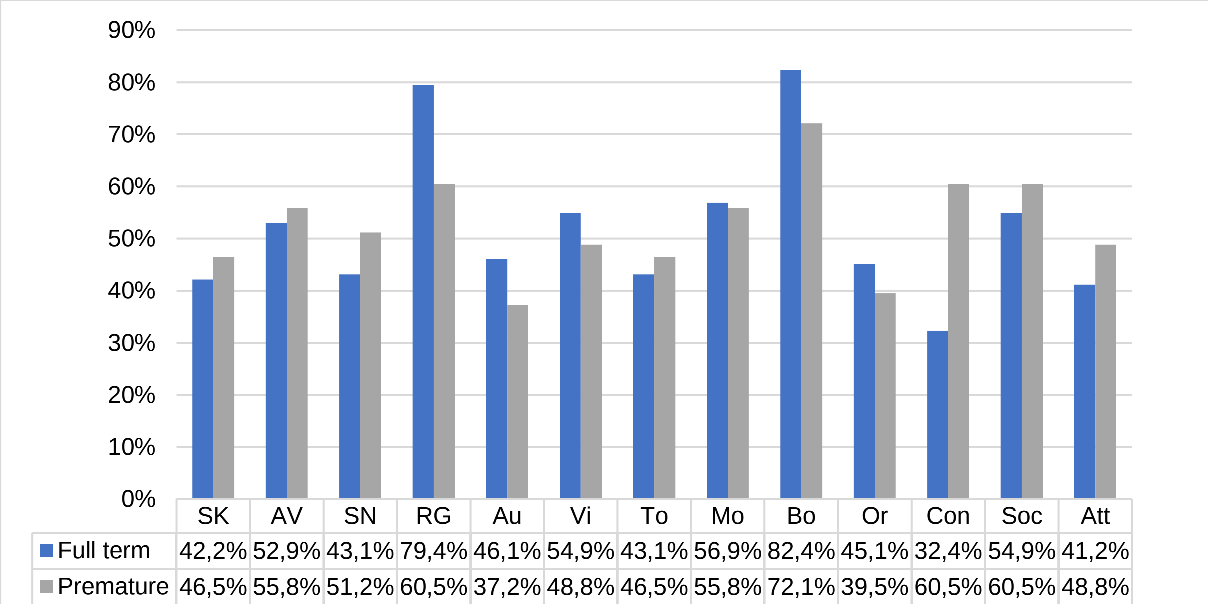
4.4.5 Duration of gestation

The next aspect considered by the researcher was the duration of gestation, that is, those born full-term in comparison to those born prematurely (figure 4.34).

The participants (n=102) who were born at full-term, presented with avoiding (52.94%) and registration (79.41%) patterns, as well as with difficulties with visual (54.90%), movement (56.86%), and body position (82.35%) processing. Additionally, they presented with social-emotional (54.90%) problems. Therefore, the participants born at full-term presented with difficulties in six out of the 13 sections.

The participants (n=43) who were born prematurely, presented with avoiding (55.81%), sensitivity (51.16%), and registration (60.47%) patterns. Within the sensory section, they had difficulties with movement (55.81%) and body position (72.09%)

processing. The prevalence of the conduct (60.47%) and social-emotional (60.47%) sections were both above 50%. Therefore, seven out of the 13 sections were problematic for the premature participants.



SK= seeking; AV= avoiding; SN= sensitivity; RG= registration; Au= auditory processing; Vi= visual processing; To= touch processing; Mo=movement processing; Bo=body position processing; Con=conduct; Soc= social-emotional; Att= attentional

Figure 4.34 Comparison between full-term and premature birth

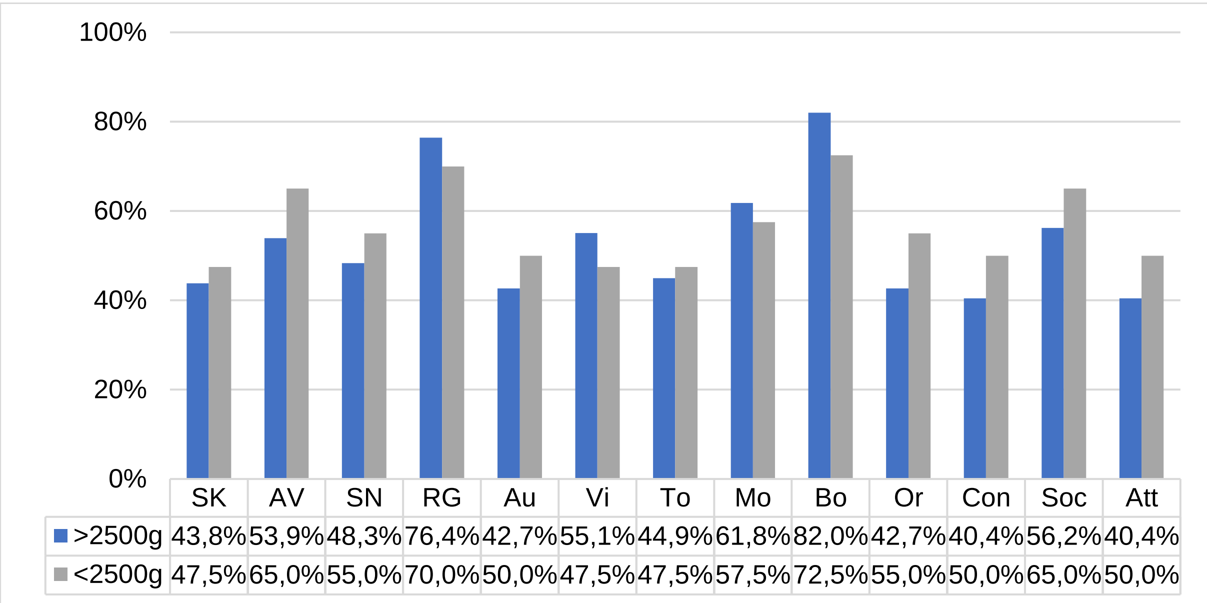
There were no statistically significant differences between the mean scores in the quadrants, sensory sections, or behavioural sections. However, the Fisher's exact test revealed that there were statistically significant differences between the proportions of participants scoring outside of the norm in the registration (p=0.023) and conduct (p=0.003) sections.

Furthermore, three differences were identified in the questions, that is, question 2, *"holds hands over ears to protect them from sound"* (p=0.042) from the auditory section; question 19, *"becomes anxious when standing close to others (for example, in a line)"* (p=0.009) from the touch section; and question 54, *"rushes through colouring, writing, or drawing"* (p=0.046) from the conduct section.

4.4.6 Birth weight

Two birth weight bands were examined and compared (figure 4.35) by the researcher. The normal birth weight (NBW) group included participants who weighed more than 2500g at birth. The NBW (n=89) participants presented with avoiding (53.93%) and registration (76.40%) patterns, as well as with difficulties with visual (55.06%), movement (61.80%), and body position (82.02%) processing. They had social-emotional (56.18%) problems. Therefore, the NBW group had difficulties in six out of the 13 sections.

For analytical purposes, children with birth weights less than 2500 grams were defined as less than normal birth weight (LNBW). The LNBW (n=40) participants presented with avoiding (65.00%), sensitivity (55.00%), and registration (70.00%) patterns. They also had difficulties with auditory (50.00%), movement (57.50%), body position (72.50%), and oral sensory (55.00%) processing, as well as conduct (50.00%), social-emotional (65.00%), and attentional (50.00%) problems. Therefore, 10 out of the 13 sections were problematic for the LNBW participants.



SK= seeking; AV= avoiding; SN= sensitivity; RG= registration; Au= auditory processing; Vi= visual processing; To= touch processing; Mo=movement processing; Bo=body position processing; Con=conduct; Soc= social-emotional; Att= attentional

Figure 4.35 Comparison between NBW and LNBW groups

There were no statistically significant differences between the proportions or the mean scores of the two birth weight groups. Despite this, three differences were found in the questions, that is, question six, *'tunes me out or seems to ignore me"* (p=0.059) from the auditory section; as well as question 18, *"shows an emotional or aggressive response to being touched"* (p=0.059) and 20 (p=0.037) from the touch section.

4.5 SUMMARY OF RESULTS

Chapter 4 discussed the results pertaining to the demographic data, as well as the objectives. The following is a summary of the main findings:

Objective 1:
In the quadrants, the registration (72.73%) and avoiding (53.90%) patterns were most prevalent in the sample of CP children (n=154). There was a significant difference (p<0.000) between the CP sample and the normative sample in all the quadrants. The CP sample presented with more passive (42.86%) than active (35.06%) self-regulatory strategies. A similar prevalence of both high (40.91%) and low (39.61%) neurological thresholds was observed. The factor analysis done on the quadrants revealed that there is a strong, linear and positive correlation between the quadrants; indicating that if a participant scores high score in one quadrant then they are likely to also have high scores in other quadrants. No clusters were identified between the quadrants.

Objective 2:
Most of the children with CP presented with body position (77.92%), movement (56.49%), and visual processing (53.25%) difficulties from the sensory sections of the SP2. There was a significant difference (p<0.000) between the CP sample and the normative sample in all the sensory sections.

Objective 3:
In the CP sample, only the social-emotional section was prevalent; occurring in 55.84% of participants. There was a significant difference (p<0.000) between the CP sample and the normative sample in all the behavioural sections.

Objective 4:

- The ataxic subtype presented with registration (71.43%), sensitivity (61.90%), avoiding (61.90%), and seeking (57.14%) patterns.
- The dyskinetic subtype presented with registration (71.43%), seeking (57.14%), avoiding (57.14%), and sensitivity (52.38%) patterns.
- The diplegic subtype presented with only registration (81.97%) and avoiding (50.82%) patterns.
- The hemiplegic subtype presented with registration (63.27%), avoiding (55.10%), and sensitivity (51.02%) patterns.
- Therefore, the ataxic and dyskinetic had difficulty in all four quadrants, the hemiplegic had difficulty in three quadrants, and the diplegic had difficulty in two quadrants.
- No statistically significant differences were found between the mean quadrant scores. However, there were statistically significant proportional differences between the ataxic and spastic diplegic subtypes (p=0.040) in the sensitivity quadrant, as well as between the spastic hemiplegic and spastic diplegic subtypes (p=0.028) in the registration quadrant.
- In general, there was a higher prevalence of passive strategies than active strategies in all the subtypes, except in the ataxic subtype which had equal percentages of both the passive and the active strategy. High neurological thresholds were more prevalent than low neurological thresholds in the ataxic, dyskinetic and diplegic subtypes. In contrast, the hemiplegic subtype had a higher prevalence of the low threshold patterns.
- There is some evidence to suggest that the null hypothesis can be rejected because there were some proportional differences between the groups in some of the quadrants.

Objective 5:

- The ataxic subtype presented with body position (76.19%), visual (66.67%), movement (66.67%), oral sensory (57.14%), and touch (52.38%) processing difficulties.
- The dyskinetic subtype presented with body position (85.71%), movement (66.67%), auditory (52.38%), and visual (52.38%) processing difficulties.

- The diplegic subtype presented with only body position (93.44%) and movement (57.38%) processing difficulties.
- The hemiplegic subtype presented with visual (57.14%), touch (57.14%), and body position (55.10%) processing difficulties.
- A statistically significant difference was reported between the mean scores of the four main subtypes in the body position processing section (p=0.000). Furthermore, a significant proportional difference (p=0.015) was found between the dyskinetic and hemiplegic subtypes, as well as between the diplegic and hemiplegic (p=0.000) subtypes in the body position processing section.
- Analysis of the 86 questions revealed eight significant differences in the questions between the four main CP subtypes. Thirteen differences occurred between the diplegic and hemiplegic groups.
- There is some evidence supporting the alternative hypothesis in some of the sensory systems.

Objective 6:

When comparing the prevalent behavioural patterns in the four main CP subtypes, all the subtypes were observed to have social-emotional difficulties. Only the ataxic participants presented with additional behavioural difficulties, namely, in the attentional (52.38%) section. One question was found to be statistically significant between the four main CP subtypes. Furthermore, only one question was found to be different between the spastic and hemiplegic subtypes. There does not seem to be a difference between the subtypes in the behavioural section; therefore, the null hypothesis can be accepted.

Other findings:

- The movement disorder group appeared to have more sensory modulation difficulties (11 out of the 13 sections) than the spastic disorder group (six out of the13 sections). There was a statistically significant difference (p=0.045) between the proportions of participants scoring out of the norm in the seeking quadrant between the two groups. Furthermore, two out of the 86 questions were identified as being significantly different between the two groups.

- The GMFCS level I (eight out of the 13 sections) and II (five out of the 13 sections) participants presented with more sensory modulation difficulties than the GMFCS level III (four out of the 13 sections) participants. There was a statistically significant difference ($p=0.001$) between the mean scores in the body position processing section between the three GMFCS levels. There were significant proportional differences identified between the three levels in the sensitivity quadrant ($p=0.041$) and the body position processing section ($p=0.001$). Furthermore, 16 out of the 86 questions were found to be significantly different ($p<0.05$) between the three levels.
- The older (six out of 13 sections) and younger (six out of 13 sections) groups had the same number of sections fall out the norm. However, the percentages in the younger group were higher than the older group, suggesting that they had more difficulty than the older group. There were statistically significant differences between the means in the sensory seeking ($p=0.038$) and attentional (0.056) sections, as well as in 12 out of the 86 questions between the two age bands.
- The female (eight out of 13 sections) sample presented with slightly more sensory modulation difficulties than the male (six out of 13 sections) sample, especially in the sensitivity and oral sensory sections. Despite this, there were no statistically significant differences identified between the groups, except in three out of the 86 questions.
- The premature (seven out of 13 sections) group had slightly more problems than the full-term group (six out of 13 sections), especially in the sensitivity and conduct sections. There were proportional differences in the registration ($p=0.023$) and conduct ($p=0.003$) sections. Furthermore, three statistically significant differences were found in the questions.
- The LNBW (10 out of 13 sections) group had more problems than the NBW (six out of 13 sections) group. Despite this, there were no statistically significant differences between the groups, except in three out of the 86 questions.

The results provided in chapter four will be discussed in chapter five.

CHAPTER 5
DISCUSSION

5.1 INTRODUCTION

This chapter will describe the results in greater detail. Interpretations will be offered based on the available literature, as well as the researcher's clinical reasoning. Section 5.2 will discuss some of the pertinent demographic data. Section 5.3 will discuss the sensory modulation patterns (quadrants), sensory section, and behavioural section results in children with CP, as outlined in objectives 1-3. The quadrant, sensory section, and behavioural section results for each of the four main CP subtypes will be discussed in section 5.4 to 5.7. Unlike chapter four, which combined the CP subtypes, section 5.4 to 5.7 will provide an overview and clinical picture of each of the CP subtypes; thereby, combining objectives 4-6. Section 5.8 will compare the main differences between the subtypes. After that, the researcher will discuss the secondary findings in the study in section 4.9. The influence of these factors on sensory modulation in children with CP will be examined. Lastly, the chapter will be summarised in section 5.10.

5.2 DEMOGRAPHIC DISTRIBUTION

5.2.1 Classification of cerebral palsy

Of the 154 participants in the study; 21 had ataxic CP, 21 had dyskinetic CP, 61 had spastic diplegic CP, 49 had spastic hemiplegic CP, and two had spastic quadriplegic CP (refer to table 4.2). The spastic subtype of CP was the most prevalent (72.72%) subtype; consistent with the findings of other studies, whereby the spastic subtype consisted of between 70-80% of cases.[97]

Although the prevalence of spastic CP was in accordance with global trends, the prevalence of spastic quadriplegic CP in this study was low. In other African countries,[107-108,119] spastic quadriplegia accounted for 40-42% of cases, whereas the prevalence in this study was only 1.30%. The low prevalence in this study can be attributed to the exclusion of participants functioning on a GMFCS levels IV and V.

These levels were excluded because the SP2 pertains to children who walk. The spastic quadriplegic subtype usually present with more severe motor impairments affecting all four limbs; therefore, they are often classified higher on the GMFCS classification scale.[116,119]

There were an unusually high number of participants with spastic diplegia (36.61%) in this study in comparison to other African studies, where the prevalence ranged from 4-14.5%.[107-108,119] There was a high incidence of prematurity (53.49%) and LNBW (52.50%) in the spastic diplegic participants in this study. This is consistent with the literature, which reported a correlation between low birth weight and prematurity in children with spastic diplegic CP.[98,106]

Another contributing factor that is relevant in the SA context, is the influence of the human immunodeficiency virus (HIV), as well as HIV encephalopathy. Spastic diplegia has been associated with HIV and HIV encephalopathy.[145-146] In this study, 28 participants (18.18%) were on antiretroviral medication or voluntarily disclosed their HIV status in the background questionnaire. Twenty-seven of the 28 participants had spastic diplegic CP, indicating that 44.26% of the diplegic sample also had a diagnosis of HIV. The high prevalence of participants with a dual-diagnosis of spastic diplegic CP and HIV, supports the literature that there is an association between the two diagnoses. Therefore, the higher prevalence of participants with spastic diplegic CP in this sample can be attributed to a few factors, namely, the higher incidences of LNBW and prematurity, as well as the prevalence of HIV in this subtype.

5.2.2 Gender

There were more males (n=94) than females (n=60) in this study, with a male: female ratio of 1.57:1. The higher prevalence of CP in males is consistent with the literature, which shows that CP is more prevalent in the male sex.[110-111]

5.2.3 Gestation

The majority of the children in this study were born at full-term, with 27.92% of the participants born prematurely. The rate of prematurity in this study was slightly higher than in other African studies, which reported prematurity in 4-15% of cases.[107,119] The literature indicates that there is a relationship between increased survival of premature infants and better health-care facilities.[106] Johannesburg is a large city with more access to medical services than other rural parts of SA, which may contribute to the higher survival of premature births than other African countries.

5.2.4 Birth weight

In this study, 25.98% of participants were born with a LNBW. This prevalence is higher than other low to middle-income settings, where the prevalence is reported to be 13-20%.[106] No studies have examined the prevalence of SMD in children born with a LNBW (>2500g); however, low birth weight is frequently associated with prematurity.[147]

5.3 SENSORY MODULATION CHILDREN WITH CEREBRAL PALSY

5.3.1 Sensory modulation patterns

The high prevalence of SMD in the CP sample in this study confirmed the findings in the literature that SMD are prevalent in children with CP.[37,68-69,79] The registration pattern was the most frequently observed pattern in this study. These findings correlate with the literature, which describes various types of SMD in children with CP, including under-responsivity.[5,67] The SP and SSP were used to examine SMD in children with CP in other studies.[37,68-69,79] These studies did not examine the quadrant patterns; therefore, a direct comparison between the quadrant scores was not possible. However, one study reported that the CP population had significantly more registration ($p<0.002$) behaviours (these results were obtained from the sensory sections of the SP) in comparison to TD children; therefore, consistent with the findings of this study.[69] Almost half of the participants scored in the more severe “Much More” band (49.35%) in the registration quadrant, which is more than 2Sd from the mean; whereas, only a smaller percentage (23.38%) scored in the “More Than” band, which is only 1Sd from the mean. The further away a child scores away from the mean, the more severe their difficulties are.[82] Therefore, this trend indicates that children with CP are likely to present with severe registration difficulties.

According to Dunn's framework, the registration pattern is associated with a high neurological threshold and a tendency to act passively.[82] The high prevalence of registration patterns indicates that children with CP are likely to take longer to respond or to complete tasks, and they may seem uninterested or lethargic. They may require more time or vigorous input to register information and to react to activities within their environments.[7] The high registration scores observed could be attributed to the damage in the motor and sensory pathways of the CNS. Some of the sensory registration items that were frequently selected by the parents/guardians, such as *"moves stiffly", or "loses balance unexpectedly",* could be explained by the primary and secondary impairments associated with CNS damage.[51,62] Many researchers have not studied SMD in children with CP because of the resultant CNS damage. However, recent advancements in neuroimaging studies indicate that both the ascending and the descending tracts contribute to the observed behaviours in CP.[46-49] Considering the latest research, sensory processing and modulation difficulties may be contributing to and even exacerbating the observed motor symptoms; therefore, their involvement should be considered.

Likewise, the researcher or clinician should examine the role of the environment and the associated impairments, and how these may be influencing the clinical presentation of the child. Typically developing children are exposed to various sensory inputs throughout their development, as well as during their play experiences. In contrast, children with CP are less able to actively explore and interact in their environment due to their motor impairments. Subsequently, they acquire less sensory experiences and feedback from their environment.[67,74,135] The decreased exposure to sensory experiences might be contributing to their registration difficulties. Associated impairments, such as contractures, pain, and visual impairments may also influence the way in which the child registers various types of sensory information. Although the child with CP presents with motor impairments, questions, such as the ones stated above, should not necessarily be excluded on this basis alone. Furthermore, it does not necessarily warrant the exclusion of the diagnosis of sensory modulation disorder. However, these questions should be interpreted carefully, and the child's context should be taken into consideration. It is also important to pair the results of the SP2 with clinical observations in order to formulate a holistic picture of the child.

Avoiding patterns were also prevalent in the CP sample. Sensory avoiders present with a low neurological threshold, in conjunction with a tendency to act against the threshold (active).[82] They may seem more bothered or overwhelmed by things that others do not notice, and they often try to avoid unfamiliar situations or sensory inputs that they do not like.[82] The most frequently selected questions pertaining to avoiding behaviours were from the social-emotional section, rather than from the sensory sections of the SP2. Children with CP may choose to avoid specific experiences or sensations through their avoidance of certain social interactions or by reacting emotionally, rather than through physical responses or reactions. Some of the questions that were selected frequently, such as *"gets frustrated easily"*, may be related to the challenges of having a disability. An avoiding pattern with a strong emotional association is not unexpected in children with CP. Due to their physical and communication limitations, they may be unable to avoid distressing or unpleasant stimuli, which may result in an intense emotional reaction. In this way, the emotional reaction is perceived more strongly than the physical reaction.

A child with muscle contractures, increased muscle tone, or uncontrolled movements due to CP may not be able to physically move away from sensations they find overwhelming. Their physical attempts to avoid sensations may be inappropriate (for example, accidently/purposefully hitting someone in attempt to get away from an overwhelming stimulus); inefficient (for example, only partially being able to cover their ears); or delayed (for example, the touch or noise may have bothered them for longer, but they may only be able to react at a later stage). On the other hand, some children may be perceived by others as avoiding an activity, but rather their physical and communication impairments impede their ability to participate in certain activities. Therefore, it is essential that the clinician reflects on all the factors which may be contributing to the child's patterns when interpreting the SP2 results.

The seeking pattern was less prevalent than the registration and the avoiding patterns in the CP sample. A child who scores high in the seeking pattern actively attempts to enhance their experience of sensory input due to insufficient neural activation.[82] The prevalence of seeking patterns was lower in this study in comparison to other disability groups, such as ADHD.[23,38] The lower prevalence of seeking patterns is likely related to the presence of more severe motor impairments in the CP population. Children with CP may be less able to seek out additional feedback due to their motor impairments.

The sensitivity pattern was also seen less frequently than the registration and avoiding patterns. High sensitivity scores are often seen in children with ASD, especially in the auditory, tactile and oral sensory aspects of the SP.[19,22] Rather than being hyper-sensitive, children with CP may be less sensitive to sensory information due to the CNS damage, which results in delayed or abnormal processing.[50-51,140] They may take longer to notice or react to sensory information due to damage to the sensory tracts. Interestingly, it has emerged that in children with CP the somatosensory cortices desynchronise in response to sensory feedback.[52] This atypical response has been linked to the responsiveness of the somatosensory cortex to afferent feedback, which may be contributing to the lower sensitivity scores in the CP population.

When examining the neurological threshold continuum (refer to figure 4.7), both the high (40.91%) and the low neurological thresholds (39.61%) occurred in less than half of the participants. There was a relatively equal distribution of both high and low thresholds, which appears to be related to the higher prevalence of both the avoiding patterns (which is a low threshold) and the registration patterns (which is a high threshold). In order to score “high” or “low”, participants had to fall out in both high or both low quadrants. It is likely that participants fell out in only one of the two, which may have contributed to the lower overall prevalence.

The prevalence of both regulatory strategies was also low, with a slight preference for the passive strategy (42.86%) in comparison to the active strategy (35.06%). The preference for the passive strategy is consistent with the higher prevalence of registration difficulties, which is a passive response according to Dunn’s framework.[82] Children who are passive do not attempt to grade or change the sensory input to meet their needs, or they rely on others to provide them with sensory information. Children with CP may present with more passive tendencies due to their decreased mobility. In some cases, they may develop learned helplessness, whereby they become increasingly dependent on others, which may enhance their passive nature. Clinically, some parents/caregivers view their children as being unable to do most or all activities due to their disability; therefore, enhancing their child's learned helplessness by doing all tasks for them.

A recent study described different sensory profile subtypes based on the prevalence of specific SMP.[127] Based on these descriptions, children with CP would fit into the "Mellow until… sensory profile", which is characterised by higher avoiding and registration scores.[127] Although these sensory profile subtypes were developed based on predominately TD children, it is interesting that the CP sample clustered into one of the subtypes. According to Little et al. (2017) the "Mellow until… sensory profile" includes children that tend to miss salient cues, but then once they have registered the input, they then display a sudden aversion to the input.[127] Both patterns may negatively affect their participation in daily activities. Understanding the sensory profile of children with CP has significant implications for therapeutic intervention. Therapy would focus on improving the child's ability to acquire sufficient sensory feedback in order to notice or register information, but to do so in such a way that the child does not become overwhelmed or overstimulated.[127] In future, other studies may include children with CP in their profiling of SP subtypes.

Lastly, this study found that there was a strong positive linear correlation between the four quadrants in the CP sample (figure 4.8). This correlation indicates that within the CP sample, participants who had high scores in one quadrant were likely to score high in other quadrants as well. Similarly, participants who had low scores in one quadrant were likely to have low scores in other quadrants. These results indicate that the quadrants seem to influence each other in the CP population. Since the quadrant scores are based on several sensory systems, further analysis is required to identify which systems are influencing each other and the overall quadrant pattern. Some participants appeared to have lower scores across the quadrants, and others had higher scores or more frequent quadrant patterns, which may indicate different clusters. However, the factor analysis did not reveal any significant clusters or groupings to conclude that the CP sample has different levels of severity of SMD. Further research and a more extensive factor analysis is required to explore this possibility further.

The sensory systems directly influence the quadrant scores and these need to be carefully considered.

5.3.2 Sensory sections

Similar to the observation within the quadrant scores, there was also a high prevalence of sensory modulation difficulties within the sensory sections. The visual, movement, and body position processing sections were the most prevalent in the CP sample. These findings are consistent with the work of other researchers who reported high frequencies of visual processing,[69] vestibular (movement) processing,[37,69,79] body position, and movement difficulties in children with CP.[37,69] The auditory, touch, and oral sensory sections were prevalent to a lesser degree.

In the visual section, the following items received a score of three or more, indicating that the behaviour occurred half the time or more: *"watches people", "enjoys looking at visual details",* and *"prefers bright colours/patterns".* These responses are indicative of an under-responsive visual system. According to the literature, children with CP have decreased exposure to visual experiences,[67] which could be contributing to the high threshold responses observed in this study. Furthermore, children with CP frequently present with cortical visual impairments, as well as other visual deficits.[89] The visual and vestibular systems are connected;[2] therefore, the observed visual processing deficits may also be associated with the deficits in the vestibular system. Interestingly, of the participants that fell out in the visual system, 14.94% scored in the "Less" band, which was much higher than the other systems. Furthermore, the percentage of children scoring in the "Less" band is significantly higher than one would expect in a typical population. The behavioural observations associated with the "More" and "Less" bands are different. Children who score in the "Less" bands do not seek, avoid, sense, or register enough visual information which interferes with their participation. The study found that children with CP have visual processing challenges associated with both the "More" and "Less" bands. These should be considered when interpreting the child's results.

Children with CP may not adequately register or react to visual information due to both primary and secondary causes. These findings have implications for therapy, as well as for the home and classroom modifications, which may be necessary to allow the child to adequately modulate visual information. Children with CP may need assistance to notice visual stimuli in their environment. Using brighter visual stimuli, larger print or contrast may assist them to register and process visual information.

Children with CP often present with vestibular modulation difficulties; such as aversive responses to movement, gravitational insecurity, and under-responsiveness.[67] The prevalence of movement processing difficulties occurred in more than half of the participants in this study; therefore, corroborating the findings in the literature. In the movement section, the following items received a score of three or more: *"hesitates going up or down curbs/steps", "loses balance unexpectedly when walking on an uneven surface",* and *"becomes excited during movement".* Although children with CP are known to present with poor balance and muscle control, insufficient processing within the vestibular (and proprioceptive) system may further aggravate their balance difficulties. Their hesitation when approaching or climbing steps could be related to their motor impairments; however, hypersensitivity in the otolith organs may affect their sense of gravity, which could also contribute to their hesitation and avoidance. They may present with a combination of both motor and sensory processing deficits, resulting in extreme avoidance. Children who become overly excited after moving may not be able to regulate or organise vestibular information adequately, resulting in increased activity levels after movement. Therefore, the frequent responses seen in the SP2 in this sample can be explained by motor, as well as by modulation difficulties.

The vestibular system influences muscle tone.[2] It directly impacts antigravity muscles through the descending tracts.[148] Through its connections to the RAS and the limbic system it affects the level of arousal, attention and mood,[2] which can indirectly affect muscle tone. A child with insufficient vestibular processing may be fearful of movement or heights, or seek movement, which could subsequently influence their tonal patterns. In this way, the vestibular system may negatively affect therapy; for example, placing a gravitationally insecure child on a therapy ball may result in fear and undesirable muscle tone. On the other hand, movement can be used to activate a child with a low level of arousal or low truncal tone, before engaging in other activities.

According to the literature, children with CP present with impaired proprioceptive processing.[5,67] Body position processing difficulties were observed in the CP sample in this study; therefore, verifying the findings in the literature. Abnormal muscle tone occurs in all the subtypes of CP, that is, increased tone in children with spasticity, low muscle tone in children with ataxia, or fluctuating muscle tone in children with dyskinesia.[96] Abnormal muscle tone negatively affects the accuracy of the afferent proprioceptive input originating from the muscles and joints.[67] The information is then incorrectly interpreted in the CNS, subsequently affecting other motor outputs, such body scheme and the execution of movement.[67]

The proprioceptive and vestibular systems are closely related via their connections in the cerebellum.[2] They both play a role in the coordination of movement,[72] as well as the development of antigravity postures.[149] The experience of gravity and different movements in different planes is essential for the integration of the vestibular system, as well as for the development of bilateral integration and crossing of the midline.[149] Children with CP take longer to acquire antigravity control, or they may be dependent on assistive devices or fixation patterns to maintain their posture against gravity.[149] Furthermore, they tend to move predominantly in the sagittal (anterior/posterior) plane, decreasing their ability to move and experience typical sensory experiences in the other planes.[149] The altered or delayed experience of gravity, and the decreased variety of movement patterns may impede their processing of vestibular-proprioceptive input, which is necessary for more refined movement patterns and modulation.

Less than half of the participants presented with auditory and touch processing difficulties in this study, which is different from the findings of other studies.[37,67,79] It is important to note that even though several questions may have high scores in the SP2, a sections raw score might still fall within the “Just Like” band. The SP2 manual suggests that the therapist should consider questions individually, as these they may still impact on the child’s functioning.[82] Interestingly, the majority of participants scored between “half the time or more” and “almost always” in four out of the eight questions in the auditory processing section. The questions included: *“reacts strongly to unexpected or loud noises”, “struggles to complete tasks when music/TV is on”, “is distracted when there is a lot of noise around”,* and *“enjoys strange noises or makes* *noise(s) for fun"*. These responses suggest that children with CP may present with some auditory sensitivity.

Fifty percent of participants displayed "*a need to touch toys/surfaces/texture"* half the time or more; therefore, reflecting some tactile seeking behaviours. These findings correlated with the results of an early study, which suggested that children with CP may seek out or prefer harder objects than softer objects.[55] Children with CP may seek additional feedback due to their decreased registration or sensation of tactile input. Sensitivity and avoiding patterns (which are low threshold patterns) were not observed in this sample; however, emotional difficulties were highly prevalent. Various contextual and personal factors could influence how a person with SOR responds.[4] Some children may exhibit intense behavioural responses, such as aggression, impulsiveness or avoidance.[4,26] Children with SOR and tactile defensiveness may exhibit irritability, poor socialisation and moodiness, which is related to the activation of the sympathetic nervous system.[4] The high prevalence of emotional and social difficulties observed in the CP group (55.84%) could therefore be indicative of SOR in the tactile system. Some children may avoid tactile experiences they dislike, masking their underlying sensitivity.

Furthermore, children with CP may not initially register the input as disturbing. Due to the cumulative effect of tactile input, a child may overreact later on in the day, to an input which is unrelated.[4] Their parents/guardians may observe the emotional response, but not in response to the actual tactile input, which may explain the lower prevalence of tactile difficulties and the higher prevalence of emotional challenges seen in this study. Moreover, they may not be able to react physically, such as pulling away, or be able to express their dislike verbally, due to their communication deficits. Therefore, their parents may not be aware of their sensitivity. The questions in the SP2 may not be sensitive enough to the manner in which children with CP display their tactile processing difficulties. It is imperative to substantiate the findings of the SP2 with observations of how they react towards various tactile experiences to provide insight into their tactile modulation.

Although several primary reasons for the observed sensory modulation difficulties in children with CP have been discussed, clinicians should also consider the secondary causes of SMD and how these may be influencing the child’s functioning. The child’s home environment is an important factor to consider, especially within the SA context. The environment may be sensory-rich or sensory-deprived. Some home environments may cause overstimulation due to overcrowding or noise. Other home environments may lack sufficient sensory stimuli due to socio-economic factors. Children living in townships may have different SMP to those living in brick homes with a garden and/or swimming pool. Having access to amenities such as running water and electricity may also influence SMP in children from low socio-economic backgrounds. For example, a lack of electricity may limit the child’s experience of hot water or lights.

The child’s ability to play and type of play exposure should also be considered. Having access to a garden, park or area to play at home would influence the child’s ability to acquire crucial vestibular, tactile, and proprioceptive information for sensory development. The motor limitations associated with CP often impedes the child’s ability to play and acquire both gross and fine motor sensory experiences. The environment could also negatively impact on the child’s play development. In low socio-economic groups, financial constraints may limit the child’s access to toys.

5.3.3 Behavioural sections

The behavioural difficulties reported in the SP2 occur in conjunction with underlying SMD in the sensory systems or quadrant patterns, and not in isolation.[82] Although behavioural difficulties were observed to be less prevalent than difficulties within the quadrant patterns and sensory sections, the prevalence was still high. More than half of the participants (66.23%) had atypical scores in one or more of the behavioural sections. Most of the CP participants in the sample presented with social-emotional difficulties, which is in accordance with the findings of other studies.[37,69] The conduct and attentional difficulties were less prevalent than the social-emotional difficulties. A similar trend, whereby the emotional difficulties (40.80%) were higher than the conduct (22.40%) and attentional difficulties (30.30%), was also observed in another study.[150]

High-frequency responses (scores of between three and five) indicated that the participants in this study needed *“more positive support”* when tasks were challenging and *“more protection than others”.* The parents/guardians felt that their children were more *“sensitive to criticism”*, had *“definite and predictable fears”,* displayed “*intense emotional outbursts´*, and tended to become *“frustrated more easily than others”*. The children in the sample also seemed to *“interact less with their peers”*. The findings in this study suggest that children with CP have more social-emotional difficulties than TD children. This correlates with the findings of Brossard-Racine et al. (2012) who reported high levels of emotional symptoms and peer problems in school children with CP, aged between six and 12 years old.[150] These challenges may be related to their disability, as well as their modulation difficulties. Modulation difficulties affect the child’s level of arousal, attention and subsequently, their ability to organise their behaviour and emotions.[4] Typically developing children can seek input more appropriately and independently, or avoid information that is disturbing them. In contrast, children with CP may not be able to meet their sensory needs independently, or they may rely on others to assist them, which may subsequently cause emotional outbursts and frustration.

In summary, children with CP present with significant SMD, which supports the findings of other studies.[37,68-71] They present with predominantly registration and avoiding patterns. These patterns are different to other conditions, such as ASD, ADHD and fragile X syndrome, which have higher prevalences of SOR and seeking behaviours.[18,22,30,38] The CP population also present with difficulties in the vestibular-proprioceptive and visual systems, which seems to contribute to their social-emotional problems. The presence of auditory and tactile difficulties should also be explored when evaluating the child with CP. The nature and causal mechanism of SMD in children with CP have proven to be challenging for most researchers to define.[5] Whether primary or secondary, if these difficulties are causing impairments in daily functioning, it warrants further assessment and intervention. Having discussed the CP population, the researcher will now discuss SMD in the main CP subtypes.

5.4 SENSORY MODULATION IN CHILDREN WITH ATAXIC CEREBRAL PALSY

5.4.1 Sensory modulation patterns

The results produced in this study indicate that all four patterns of sensory modulation are prevalent in the ataxic CP subtype. Registration patterns were the most common sensory modulation pattern, occurring in 71.43% of participants (figure 4.17). The ataxic subtype had the second highest recording of sensory registration difficulties in this study. These findings are in accordance with the findings in the literature, which hypothesised that children with ataxic CP struggle with sensory registration.[5] Sensitivity and avoiding patterns occurred in 61.90% of participants, with 57.14% of participants presenting with seeking patterns. The additional challenges present in the other quadrants were not reported in the literature. Therefore, the findings in this study suggest that children with ataxic CP present with general SMD.

Both regulatory strategies, active and passive (57.14%), as well as both neurological thresholds, high (57.14%) and low (52.38%) were prevalent in more than 50% of participants (figure 4.18). These findings resemble the clinical picture of the “intense sensory profile”, which is characterised by simultaneously high scores across the quadrants.[127] A larger number of participants scored in the “Much More” band than in the “More Than” band within the avoiding, sensitivity, and registration quadrants; therefore, indicating that their difficulties are more severe in these quadrants. Since all four patterns were prevalent, children with ataxic CP may fluctuate between the high and low neurological thresholds within a sensory system, or they may have different threshold responses in the different sensory systems. The involvement of the cerebellum, which is thought to have a significant influence on sensory processing and modulation, might be contributing to this general pattern of dysfunction.[151] The severity and diversity of SMP seen in the ataxic subtype may be related to the fact that the cerebellum connects to several areas of the brain.[137,151]

Due to the variety of SMP in the ataxic subtype, careful consideration is required by the clinician to determine which sensory systems may be contributing to the different patterns, so that appropriate intervention strategies and recommendations can be developed. A sensory diet, rich in a variety of sensory experiences, should be considered to cater for the child’s different sensory needs.

5.4.2 Sensory sections

The visual, touch, movement, body position, and oral sensory processing sections proved to be areas of difficulty for the ataxic subtype (figure 4.25). The high scores observed in the sensory sections can be linked to the sensory integrative function of the cerebellum, especially in the vestibular, visual, proprioceptive, and somatosensory systems.[137] A higher percentage of participants scored in the "Much More" band than in the "More Than" band in the visual, touch, movement, and body position sections. These findings indicate that they tend to experience more severe difficulties in these areas, which is consistent with the "intense sensory profile" observed in the quadrants.

Although less than 50% of the participants experienced auditory processing difficulties (47.62%), four out of the eight questions had high scores in this section. They *"react strongly to unexpected or loud noises"*, *"struggle to complete tasks when music/TV is on"*, *"become distracted when there is a lot of noise around"*, and *"seem to tune out"* half the time or more. The majority of these difficulties are low threshold responses, typical of auditory sensitivity, which may be contributing to the high prevalence of low threshold patterns seen in the ataxic subtype. Auditory processing is a function of the cerebellum, which may explain the presence of auditory processing difficulties in the ataxic subtype.[137]

Although visual processing difficulties were observed in most of the subtypes, except for the spastic diplegic subtype, the ataxic subtype presented with the highest prevalence of visual processing difficulties. Children with ataxia had more frequent high threshold responses than low threshold responses in the visual system, indicating that they may seek out additional visual stimuli or have difficulty registering visual input, or both. There is growing evidence to suggest that the cerebellum is involved in visual sensory processing through its connections to the visual cortex, which may be contributing to the difficulties observed in the ataxic subtype.[137]

The high prevalence of vestibular-proprioceptive processing difficulties in this subtype was anticipated based on the literature; which indicated that children with ataxia had decreased vestibular-proprioceptive feedback, as well as vestibular modulation difficulties.[5,67] Children with ataxic CP are unable to coordinate and grade their movements due to cerebellar damage.[135,137] The cerebellum is involved in the processing of both vestibular and proprioceptive information.[137]

Further examination of the high-frequency responses (a score of three or more) in the movement and body position processing sections of the SP2, revealed predominantly high threshold behaviours. These difficulties included: *"pursues movement to the point that it interferes with daily routines", "becomes excited during movement", "props to support self",* and *"walks loudly"*. The findings of this study support the literature stating that children with ataxic CP present with high neurological thresholds or under-responsivity towards vestibular input.[67] Children with ataxic CP tend to fluctuate between the passive (registration) and active (seeking) strategies within the vestibular and proprioceptive systems. At times they may be under-responsive and require more intense input to activate themselves and register these sensations. At other times they may actively seek out input. They may need assistance to acquire the appropriate type and intensity of input to meet their sensory needs. These fluctuations between passive and active responses may be perceived as an attentional or behavioural problem. Interestingly, the ataxic subtype was the only CP group to score high in the attentional section in the SP2.

When examining the frequency of tactile processing difficulties in the ataxic subtype, there was a combination of both high and low threshold patterns. The prevalence of both could indicate that children fluctuate between the two thresholds, that is, they score high in some high threshold behaviours and some low threshold behaviours. Alternatively, each child may present with unique differences, with some children presenting with tactile sensitivity, and others presenting with under-responsivity. Upon further examination, there was a higher prevalence of low threshold responses in the children who scored outside of the norm, indicating that these children are likely to present with more sensitivity or avoidant behaviours. However, some children may also have seeking or low registration patterns within the tactile system.

The tactile, vestibular and proprioceptive systems contribute to the body scheme of the child.[2,13] The high prevalence of vestibular, proprioceptive, and tactile difficulties in the ataxic subtype indicates that they are likely to also present with an impaired body scheme, which may further impede their balance and coordination. As discussed previously, sensory processing deficits can negatively impact on the child's motor performance. Therapy should create opportunities for the child to experience vestibular, proprioceptive, and tactile inputs, through play, to improve their feedback and body scheme. Improving their sensory processing and modulation, as well as their feedback, will, in turn, influence their feedforward mechanisms, and improve the overall quality of their motor execution.

Oral sensory processing problems were unique to this subtype. The most frequent responses in the SP2 suggest that children with ataxia can be picky eaters, whereby they tend to reject particular tastes or smells, as well as textures. These behaviours are consistent with oral sensitivity, which may cause distress during meal times. The high prevalence of these behaviours may be associated with oral dysphasia due to their muscle coordination difficulties. The clinician would need to investigate which foods the child is sensitive towards or avoiding so that treatment can address these, possibly in conjunction with a speech therapist. Interestingly, the ataxic CP sample also presented with a high prevalence of seeking behaviours, such as putting objects in their mouth or chewing on items. They may seek oral-proprioceptive feedback, through chewing and sucking, to regulate their sensitive oral sensory systems.

5.4.3 Behavioural sections

The ataxic subtype presented with a high prevalence of social-emotional and attentional difficulties within the behavioural sections of the SP2 (figure 4.29). Conduct difficulties were prevalent to a lesser degree. These results could not be compared to other studies as none of the other studies included children with ataxic CP. However, the latest research indicates that the cerebellum is involved in the regulation of affect. Furthermore, studies show that cerebellar lesions can lead to emotional dysregulation.[152]

Social-emotional difficulties appear to be a general challenge for children with CP. However, the ataxic subtype had higher incidences of stubborn or uncooperative behaviour, temper tantrums, and decreased frustration tolerance. These behaviours are consistent with emotional dysregulation, which is associated with cerebellar lesions.[152] The emotional difficulties associated with this subtype may be related to the low threshold patterns seen in the auditory, tactile and, oral sensory systems. As mentioned previously, low threshold patterns frequently present with emotional difficulties.

The cerebellum plays a role in attention; therefore, it is not surprising that this subtype presented with the highest prevalence of attentional difficulties.[137,152] These challenges may also be influenced by their fluctuating level of arousal, as discussed above. The high-frequency responses recorded in the SP2 suggest that they struggle with concentration, are visually distracted by objects/people and tend to jump between activities. They tend to do things in a harder way and rush through tasks, which may also affect their behaviour and performance.

There appears to be a correlation between the high scores observed in the quadrants and sensory sections, and the behavioural challenges observed in the ataxic subtype. Children with ataxic CP presented with more severe SMD than the other subtypes, which seems to negatively affect their attention and social-emotional functioning.

In summary, children with ataxic CP presented with severe, general sensory modulation difficulties in all four quadrants, resulting in attentional and socio-emotional problems. All the sensory systems were involved.

5.5 SENSORY MODULATION IN CHILDREN WITH DYSKINETIC CEREBRAL PALSY

5.5.1 Sensory modulation patterns

The dyskinetic subtype also had more than 50% of participants scoring outside of the norm in all four quadrants, similar to the SMP observed in the ataxic subtype. These findings are consistent with the literature, which indicates that children with dyskinetic CP present with general sensory modulation deficits.[5] The most prevalent pattern in this subtype was the registration pattern (figure 4.17). The dyskinetic subtype also presented with an “intense sensory profile”, as observed in the ataxic subtype.[127] However, unlike the ataxic subtype, which reported higher percentages in the “Much More” band; the dyskinetic subtype had higher percentages in the “More Than” band in the seeking, avoiding, and sensitivity quadrants. The majority of participants scored in the “Much More” band in the registration quadrant. Therefore, it can be assumed that the dyskinetic CP subtype has less severe sensory modulation problems than the ataxic CP subtype, especially in the seeking, avoiding, and sensitivity quadrants.

Both the self-regulatory strategies occurred in less than 50% of participants; however, the passive strategy (47.62%) occurred more frequently than the active strategy (42.86%). This trend suggests that children with dyskinetic CP tend to act in accordance with the neurological threshold rather than act against it (figure 4.18).[82] The high neurological threshold (52.38%) was more prevalent than the low neurological threshold (42.86%); therefore, supporting the findings in the literature reporting that children with dyskinetic CP are under-responsive.[67] The high threshold responses observed in this subtype included both registration and seeking patterns. The presence of fluctuating muscle tone or dystonia in this subtype, impedes their ability to control their movement, which may hamper their mobility, as well as their ability to acquire sensory feedback. Subsequently, their nervous systems may require more intense sensory input before registering or reacting to the information, which may result in sensory seeking behaviours in an attempt to acquire sufficient feedback.[38] The prevalence of seeking behaviours was unique to the ataxic and dyskinetic CP subtypes. The next section will examine the involvement of the specific sensory systems.

5.5.2 Sensory sections

The dyskinetic subtype presented with auditory, visual, movement, and body position processing difficulties (figure 4.25). Tactile and oral sensory processing difficulties occurred less frequently. The participants tended to score in the "More Than" band, except in the body position processing section, which had a higher prevalence in the "Much More" band. Dyskinetic CP has been linked to lesions in the thalamus, basal ganglia, and peri-rolandic cortex.[144] More recently other areas, such as the cerebellum, brainstem and cerebral cortex have also been associated with dystonia.[138] These areas are all involved in sensory processing and may therefore be contributing to the modulation difficulties observed in this subtype. The basal ganglia are considered to act as a gate for all sensory input.[101] It plays a critical role in selecting the stimuli appropriate for cortical attention by releasing the inhibition on the thalamus. The basal ganglia also inhibits subcortical areas from over-responding to sensory information. In this way, the basal ganglia can be associated with sensory modulation.[151]

Vestibular-proprioceptive processing difficulties frequently occurred in this subtype, which corresponds with the literature indicating that the children with dyskinetic CP present with vestibular-proprioceptive processing difficulties.[5,67] The damage to the CNS structures mentioned above results in fluctuating muscle tone and motor impairments, which could be contributing to these challenges. Abnormal muscle tone and motor impairments negatively influence the afferent and efferent pathways, which, in turn, affect the processing and modulation of these inputs.

The movement processing responses that were selected the most frequently included: *“pursues movement to the point that it interferes with daily routines”, “rocks in chair, on floor, or while standing”, “becomes excited during movement”,* and *‘loses balance unexpectedly when walking on uneven surfaces”.* The majority of these behaviours are sensory seeking behaviours. The dyskinetic subtype presented with more sensory seeking behaviours within the vestibular system than the other CP subtypes. Interestingly, 95.24% of the participants became excited during movement half the time or more; suggesting that they enjoy movement, and actively seek opportunities to acquire movement. These findings have therapeutic implications, indicating that children with dyskinetic CP may require regular opportunities to acquire movement and proprioceptive inputs, through play, to enhance their body scheme and sensory processing.

The literature indicated that children with dyskinetic CP present with poor tactile processing.[5,59] However, the children with dyskinetic CP in this study, presented with the least tactile processing difficulties. A few factors may have influenced the scores in the study. Firstly, the findings in the literature might have focused on tactile discrimination deficits,[59] whereas this study focused on the tactile modulation difficulties. Secondly, the studies in the literature did not use the SP; therefore, it is difficult to compare the results directly.

The low scores observed in the tactile processing section in this study does not necessarily mean that children with dyskinetic CP do not have tactile modulation difficulties. The specific questions in the SP2 may not have identified the tactile difficulties that they do experience. Furthermore, it was found that five-to-ten percent of the participants had a zero score in ten out of the 11 tactile questions. When interviewed, several parents/guardians indicated that they felt as though these questions were not relevant because their child was unable to use their hands. The presence of increased or changing muscle tone and involuntary movements often makes it difficult for children with dyskinetic CP to use their hands, which may explain the high prevalence of DNA responses in this subtype. Of the children who scored in the "Much More" or "More Than" bands, the majority had seeking and registration difficulties. These findings suggest that children with dyskinetic CP may not appropriately register tactile inputs, and they may seek additional feedback. Further investigation through observation and interviews may provide further insight into the types of tactile problems they might have. Other studies should also examine the differences between the choreoathetotic and dystonic CP subtypes, as their tactile processing may differ.

In addition to the findings of other studies, this study also reported auditory and visual processing difficulties in the dyskinetic subtype. High scores in the auditory section were unique to this subtype. Upon further examination, children with dyskinetic CP appear to be more sensitive and avoiding towards auditory stimuli. Therefore, they display lower threshold responses within the auditory system. This may negatively influence their participation and concentration in noisy environments, such as at school and in public areas.

The visual processing system had a higher prevalence of seeking behaviours, indicating that they seek more intense visual stimuli than typically developing children. Both the auditory and visual systems had 9.52% of participants scoring in the "Less Than" band. Children scoring in the lower bands will have different challenges to children scoring in the higher bands, and this should be taken into consideration when interpreting the results. The next section will discuss the impact of the sensory sections on the behavioural responses in the dyskinetic CP subtype.

5.5.3 Behavioural sections

The majority of the children with dyskinetic CP presented with social-emotional difficulties (figure 4.29). Common difficulties reported by the parents/guardians were: my child is "*stubborn and uncooperative"*, has "*temper tantrums"*, has "*definite and* *predictable fears",* has "*strong emotional outbursts*", and *interacts less"* with others. Clinically, this subtype often present with social and emotional challenges, although no research was found to support this observation. Children with dyskinetic CP often have severe motor and speech deficits which may impact on their behaviour, social skills, and emotional regulation.[101] Furthermore, the presence of intense sensory modulation difficulties may also be contributing to the socio-emotional challenges observed in clinical practice. Less than half of the participants presented with attentional and conduct difficulties.

In summary, children with dyskinetic CP presented with general modulation difficulties in all four quadrants, resulting in socio-emotional difficulties. Their modulation challenges appear to stem from primarily the vestibular-proprioceptive, auditory and visual systems.

5.6 SENSORY MODULATION IN CHILDREN WITH SPASTIC DIPLEGIC CEREBRAL PALSY

5.6.1 Sensory modulation patterns

Registration patterns were the most commonly observed in this subtype, with the majority of participants scoring in the most severe band (figure 4.17). The avoiding quadrant was the second most prevalent pattern. The seeking and sensitivity patterns only occurred in 36.07% of participants, less than the other CP subtypes. In general, the spastic diplegic subtype appeared to have fewer modulation difficulties than the other subtypes.

The low (31.15%) and high (36.07%) neurological thresholds occurred in less than 50% of the participants, with slightly more participants presenting with high threshold patterns. Similarly, the prevalence of the active (29.51%) and passive (36.07%) strategies were low, with a slight preference for the passive regulatory strategy (figure 4.18). The low prevalence (less than 50%) of the passive strategy found in this study did not correlate with the literature, which indicated that children with spasticity are more likely to be passive.[67] The passive strategy is comprised of both the registration and sensitivity patterns. The spastic diplegic subtype presented with a high prevalence of registration patterns, but a low prevalence of sensitivity patterns. The lower incidence of sensitivity patterns, therefore, influenced the frequency of the overall passive response. The spastic diplegic subtype had the highest prevalence of registration patterns in comparison to the other subtypes, indicating that they do have some passive tendencies, especially in the high neurological thresholds.

The registration patterns were observed to be more prevalent in the GMFCS level III group (figure 4.31), suggesting that there may be a correlation between the motor impairments and registration patterns. Children with spastic diplegic CP frequently rely on assistive devices due to their increased tone and weakness in their lower limbs, resulting in them being classified higher on the GMFCS scale. The participants in this study were predominantly (63.93%) classified as functioning on GMFCS level III. Therefore, the higher prevalence of GMFCS level III participants in the spastic diplegic subtype may be contributing to the high incidence of registration patterns. Similarly, the low prevalence of seeking patterns in this subtype may be related to their decreased mobility. Therefore, the prevalence of high registration and low seeking patterns in children with diplegic CP could be associated to the level of mobility and independence.

The SMP observed in the diplegic subtype resemble the “mellow until.., sensory profile”, which presents as a combination of avoiding and registration patterns. This is the same pattern prevalent in the general CP population. Children with spastic diplegia may fluctuate between under-responsivity (low threshold) and over-responsivity (high threshold), which could negatively affect their participation in daily activities. The sensory systems which could be contributing to these difficulties will be discussed in 5.6.2.

5.6.2 Sensory sections

The movement and body position processing sections were the only sensory systems identified as problematic in the spastic diplegic subtype (figure 4.25). A high percentage of the participants scored in the “Much More” band in the body position processing section, indicating that they had severe difficulties in this sensory system. The auditory, visual, touch, and oral sensory processing sections occurred in less than half of the participants; suggesting that these systems were less problematic in the spastic diplegic sample.

This study did not observe a high prevalence of auditory processing difficulties in the spastic diplegic subtype, which is in contrast to other studies.[68,70] The reason for this difference may be related to the sensitivity of the auditory processing section in the SP2. The other researchers used the SSP, which may also explain the differences in the results obtained between the studies. Despite the majority of participants scoring in the "Just Like" band, more than half of the participants scored between "half the time" and "almost always" in five of the eight auditory questions. Therefore, auditory processing, especially sensitivity/avoiding patterns, may be an area of concern for some children with spastic diplegic CP.

The literature indicates that children with spastic diplegic CP have vestibular-proprioceptive processing difficulties.[68,70] The high prevalence of both movement (vestibular) and body position (proprioceptive) processing challenges identified in this study could be attributed to the increased muscle tone in their lower limbs which, in turn, negatively affects their ability to walk. Although some of their difficulties could be related to their physical limitations, especially in the questions that pertain to standing and walking; the presence of vestibular-proprioceptive deficits are consistent with the literature, and therefore these results cannot be discredited entirely.[5,67] However, they should be interpreted carefullly, and in conjunction with other observations.

Children with spastic diplegic CP are reported to have vestibular modulation difficulties, such as gravitational insecurity and aversive responses to movement.[5,68] Gravitational insecurity occurs as a result of poor processing and modulation in the otolith organs, whereas aversion to movement is related to the semi-circular canals.[2] Children who are unable to process vestibular information adequately may display an intense fear when they are lifted or placed on an unstable surface, they may dislike having their feet off the ground, or they may overreact when they are moved, especially when moving backwards.[67]

Only 1.64% of the spastic diplegic CP sample were able to walk independently (GMFCS level I). Delayed physical milestones are typical in this subtype, with most children only walking between the ages of two and four years old.[153] Consequently, their ability to assume antigravity postures, especially standing and walking, is also delayed. The head position, and thereby the position of the vestibular organs; the centre of gravity; and the weight-bearing position changes when the child moves from the floor to standing or walking. These changes alter the vestibular and proprioceptive feedback they acquire, as well as their body scheme.

Furthermore, children with spastic diplegic CP frequently avoid using the frontal and transverse planes, preferring only the sagittal plane. This may also influence their centre of gravity and their experience of lateral and rotational movements. A TD child integrates and modulates vestibular information by experiencing different types of movement in all planes, such as running, climbing, spinning, rolling, and skipping. Therefore, the combination of delayed acquisition of motor milestones, altered vestibular experiences, and decreased exposure and integration of vestibular information might be influencing the integration and modulation of vestibular information in children with spastic diplegic CP.

The movement section in the SP2 only contains high threshold patterns, and the modulation disorders mentioned above are low threshold behaviours. Hence, the researcher could not determine these specific types of modulation difficulties from the SP2 questionnaire. However, upon further investigation, it was found that 57.38% of participant had high scores (between three and five) for: *"hesitates going up or down curbs"*. Moreover, 78.69% of participants scored between zero and two (low-frequency) for "*takes excessive risks (for example, climbs high into trees, jumps off tall furniture) that compromise own safety"*. These responses suggest that these children may be sensitive to gravitational input, resulting in their avoidance. Despite the fact that children with spastic diplegic CP present with vestibular modulation difficulties in clinical settings, there is insufficient evidence to conclude this based on the results obtained from this study. Therefore, further investigation through observations and interviews are recommended to confirm the presence of gravitational insecurity or vestibular over-responsivity in children with spastic diplegic CP. Further research, using a tool which includes SUR and SOR within the vestibular system is required. This will provide clarity on the specific vestibular modulation challenges prevalent in children with spastic diplegic CP.

The literature is unclear and contradictory with regards to tactile processing in spastic diplegia, reporting both increased and decreased responses to tactile input during handling.[5] Furthermore, whether these difficulties relate to tactile discrimination or modulation is not specified. One study using the SP reported tactile sensitivity,[68] whereas another did not.[70] Less than 50% of children with spastic diplegic CP in this study presented with touch processing difficulties. Spastic diplegia affects the lower limbs more than the upper limbs, and therefore the hands are less affected. This may provide some explanation for the lower prevalence of tactile scores in this subtype. Children with diplegic CP often use their hands to mobilise, and in doing so, they acquire a lot of tactile and deep pressure inputs, which may integrate this type of sensory information.

Upon closer examination, high threshold patterns appeared to be more prevalent in those that fell out in the touch processing section. Problems included: *"displays need to touch toys/surfaces/textures"* and *"seems oblivious to messy hands or face"*. Therefore, some children may have under-responsive tactile systems, which may influence their discrimination of tactile input. It could be argued that because they use their hands for mobility and stability, they do not develop adequate tactile discriminatory sensory functions. Another study could explore this hypothesis further.

5.6.3 Behavioural sections

Social-emotional difficulties were also prevalent in the spastic diplegic CP sample, in a similar proportion to the other subtypes (figure 4.29). The conduct and attentional sections occurred in less than 50% of participants. This subtype had the lowest prevalence of attention difficulties.

In summary, this study found that children with spastic diplegic CP were likely to experience registration and avoiding SMP. They had under-responsive proprioceptive and vestibular systems, with possible under-responsivity in the tactile system. Due to the nature of the SP2, sensory over-responsivity could not be confirmed in the vestibular system. However, this should be considered in the assessment and treatment of the child with spastic diplegic CP. These SMD contribute to their socio-emotional problems.

5.7 SENSORY MODULATION IN CHILDREN WITH SPASTIC HEMIPLEGIC CEREBRAL PALSY

5.7.1 Sensory modulation patterns

The avoiding, sensitivity, and registration patterns were prevalent in the spastic hemiplegic CP subtype (figure 4.17). More participants scored in the “Much More” band than in the “More Than” band in all the quadrants. As observed in the diplegic subtype, the hemiplegic subtype also had a low prevalence of seeking patterns.

The high prevalence of registration difficulties is consistent with the findings in the literature, which reported sensory dormancy and under-responsiveness in the spastic hemiplegic subtype.[5,68] Children with spastic hemiplegic CP presented with fewer registration difficulties in comparison to the other subtypes. This observation could be related to the severity of their motor impairments. The majority of children with hemiplegia were classified as functioning on GMFCS level I, indicating that their mobility was less impaired.[116] Subsequently, they are more able to move with greater independence. Furthermore, one side of their body is unaffected or affected to a lesser degree. One might argue that their increased mobility and the intact sensorimotor functioning on the non-hemiplegic side allows them to experience and register more sensory input; therefore, providing an explanation for the lower registration scores.

The prevalence of avoiding and sensitivity SMP in this study correlates with the literature indicating that children with spastic hemiplegic CP present with sensory defensiveness.[5] The next section will analyse the sensory systems which could be contributing to these quadrant patterns.

The active strategy (30.61%), passive strategy (44.90%), high neurological threshold (34.69%), and low neurological threshold (44.90%) occurred in less than 50% of participants (figure 4.18). As seen in the other subtypes, the passive strategy was more prevalent than the active strategy, which is consistent with the findings in the literature stating that passivity is related to spasticity.[67] However, in contrast to the other CP subtypes, the low neurological threshold occurred more frequently than the high threshold. The high prevalence of avoiding and sensitivity patterns, which are both low thresholds, appears to be contributing to the predominantly low threshold pattern observed in this subtype.

Children with hemiplegic CP meet the criteria for both the “vigilant sensory profile” (high scores in the avoiding and sensitivity quadrants) and “mellow until… sensory profile” (high scores in the registration and avoiding quadrants). Their SMP indicate that they have difficulty registering some types of sensory information and are over-responsive towards other types of sensory information.

5.7.2 Sensory sections

Visual, touch, and body position processing difficulties were the most prevalent in the hemiplegic CP subtype. The auditory, movement, and oral sensory difficulties occurred in less than 50% of the hemiplegic participants (figure 4.25).

High-frequency responses in the visual system indicate that children with spastic hemiplegic CP seek out additional visual information, which is consistent with a high threshold response. The percentage of children presenting with auditory difficulties was lower than 50%. Despite this, four out of the eight questions were prevalent half the time or more in more than half of the participants. The high frequency of sensitivity and avoiding responses in the auditory items, suggests that some children may present with low threshold patterns in the auditory system, which is consistent with the findings in the literature.[68]

Children with hemiplegic CP are reported to have tactile and proprioceptive processing difficulties, which subsequently affects their motor planning.[5,58,67] These difficulties are commonly observed in clinical settings. The sample is this study also presented with tactile-proprioceptive processing difficulties. Interestingly, this subtype had the highest prevalence of touch processing difficulties. Soomro et al. (2011) reported tactile sensitivity in the hemiplegic CP population.[68] In contrast, there was a high frequency of both the high and low threshold responses in this study. There are a few explanations for the prevalence of both patterns. Firstly, some children may initially not register tactile information (high threshold) but they may then become overstimulated or aversive towards the input later on (low threshold). Some children may seek out (high threshold) soothing or deep pressure inputs by touching others or toys to regulate or modulate unpleasant (low threshold) sensory information. Alternatively, some may respond differently to different tactile sensations, resulting in fluctuating patterns. The clinician should carefully consider what is happening in the tactile system when assessing the child with spastic hemiplegia. Fluctuations within a system are not uncommon, even in the TD population.

Several factors may influence tactile processing and modulation in the children with spastic hemiplegic CP. Children with hemiplegia frequently have asymmetrical postures and weight-bearing. They may also present with neglect of the affected side,[67] resulting in atypical sensation and movement. Hemi-neglect is thought to be caused by the decreased awareness of the affected side. This neglect may then result in sensitivity over time, due to the lack of exposure to various stimuli. Some children with hemiplegic CP actively avoid using the affected side in activities. It could be postulated that their hypersensitivity, especially in the hand, contributes to this perceived neglect or avoidance. These manifestations of neglect may be contributing to the high prevalence of sensitivity and avoiding patterns in the hemiplegic subtype. Both neglect and avoidance can negatively influence their tactile modulation.

Furthermore, uneven weight-bearing through the limbs may alter their experience of somatosensory feedback, resulting in conflicting sensory messages in the cortex. Through crawling, TD children acquire proprioceptive and different tactile inputs through the upper limbs, which, in turn, has an integrating and organising effect. Children with hemiplegia frequently crawl in an asymmetrical pattern, bottom-shuffle to avoid using their hands, or avoid crawling altogether. In this way, their experience of proprioceptive and tactile sensations is diminished or atypical. Subsequently, they may be less able to integrate and modulate these inputs, especially in their hands. Recent research has found evidence that interhemispheric reorganisation occurs in the motor systems. In this way, other areas of the brain can take over the functions in the damaged areas, particularly when the lesion happens earlier on in development.[39,50,64,66,154] Some researchers argue that the somatosensory system is unable to reorganise in the same way.[39,154] If this is the case, the lack of integration of the two hemispheres may explain the presence of tactile sensitivity in the hemiplegic CP population.

The hemiplegic subtype presented with typical movement processing, whereby the majority scored in the “Just Like” band, indicating that they have less vestibular difficulties than the other CP subtypes. This is consistent with the findings in another study, which reported that the hemiplegic subtype was less sensitive to movement in comparison to the other spastic subtypes.[68] Furthermore, they also presented with less proprioceptive processing difficulties in contrast to the other subtypes. The decreased occurrence of vestibular-proprioceptive processing difficulties in this subtype can be attributed to their lower GMFCS level. The majority of them walk with minimal impairments, allowing them more freedom to move and to experience various types of movement. The behavioural responses will be discussed next.

5.7.3 Behavioural sections

The behavioural patterns (figure 4.29) observed in the spastic hemiplegic subtype were similar to the dyskinetic and diplegic subtypes. There was also a with a high prevalence of social-emotional difficulties including; *“can be stubborn and uncooperative”, “has strong emotional outbursts”,* and *“gets frustrated easily”.*

Although attentional difficulties were less prevalent, the parents/guardians reported that their children with spastic hemiplegic CP had trouble concentrating. Their concentration difficulties could be related to their sensitivity and avoiding patterns, especially in the auditory and tactile systems. Recent studies provide support for Ayres’ initial hypothesis,[72] that there is a relationship between tactile defensiveness and attention difficulties.[133] This study also found an association between high tactile scores and attention difficulties in the spastic hemiplegic (and ataxic) subtype. The prevalence of conduct difficulties was lower in this subtype in comparison to the other subtypes.

To summarise the findings in the hemiplegic subtype, low threshold and registration patterns were the most prevalent in the quadrant sections. Within the sensory systems, the visual, tactile, and proprioceptive systems occurred in more than 50% of participants. These difficulties may be contributing to the high scores in the social-emotional section. The next section will discuss the main differences between the subtypes of CP, including those that were statistically significant.

5.8 COMPARISON OF SENSORY MODULATION IN THE DIFFERENT CEREBRAL PALSY SUBTYPES

5.8.1 Sensory modulation patterns

When comparing various groupings of CP, no statistically significant differences occurred between any of the mean scores in the four quadrants (table 4.7). However, when cross-comparing the proportions of participants, there were significant differences in the sensitivity quadrant between the ataxic and diplegic subtypes, as well as in the registration quadrant between the diplegic and hemiplegic subtypes. Therefore, there is some evidence to support the alternative hypothesis.

Upon further analysis, the ataxic subtype presented with more sensitivity patterns than the diplegic subtype. Interestingly, sensitivity patterns were prevalent in more than 50% of participants in all the subtypes, except for the spastic diplegic subtype. Many clinicians use deep pressure and proprioceptive inputs, such as deep joint compressions to treat sensory sensitivity in children, because the DCML tracts have a modulating effect on the anterolateral system.[2] A possible explanation for the lower prevalence of sensitivity patterns in the diplegic subtype in comparison to the other subtypes could be related to the manner in which children with spastic diplegic CP mobilise. Children with diplegia frequently crawl, cruise along furniture, or use assistive devices. These forms of mobility would provide increased proprioceptive information through their upper limbs, which may, in turn, allow them to modulate and decrease their sensitivity.

The second significant difference occurred in the registration quadrant between the spastic diplegic and hemiplegic subtypes. In this case, the diplegic subtype presented with more registration difficulties in comparison to the hemiplegic subtype. This difference appears to be related to the level of mobility, as discussed previously. The majority of the diplegic subtype participants were classified as GMFCS level III, whereas the majority of the hemiplegic subtype participants were classified as GMFCS level I. Therefore, this study provides further support to the research done by Park (2017) which indicates that GMFCS levels contribute to SMP in children with CP.[71]

Descriptive statistics, such as percentages, also revealed clinically significant differences between the subtypes. Firstly, both the registration and avoiding patterns were prevalent in all the subtypes; therefore, suggesting that these strategies are common to all the subtypes of CP. Secondly, sensory seeking patterns occurred more frequently in the ataxic and dyskinetic subtypes, than in the spastic subtypes. The prevalence of these behaviours may be related to the type of motor impairments present in the different subtypes. Children with ataxic CP and dyskinetic CP may be less constrained in their movements than children with spastic types of CP, allowing them to seek out additional sensory feedback. A possible hypothesis is that the lesions occurring in the cerebellum, thalamus, and basal ganglia are more likely to result in seeking behaviours more than cortical lesions. Another contributing factor could be that the parents/guardians may have misinterpreted the excess or uncontrolled movements in children with ataxic and dyskinetic CP, as seeking behaviours. Therefore, careful analysis is required when assessing the child with movement disorders.

As discussed previously, the ataxic and dyskinetic subtypes had high scores across all four quadrants, whereas the hemiplegic subtype scored high in only three quadrants. The spastic diplegic had high scores in just two quadrants. Although there is some evidence that the different subtypes presenting with unique SMP, these differences were not substantial enough to produce statistically significant results in all the sections. Nevertheless, the subtle differences cannot be discredited. There was a slight trend in the data obtained in this study, which could suggest that there are different levels of severity of SMD in children with CP. Little (2017) reported clusters based on the prevalent quadrants in TD children and some children with disabilities. This study provides some weak evidence that children with CP may present with either low, moderate, or high SMD. A more detailed cluster analytical study using a larger sample is required to explore this hypothesis further.

5.8.2 Sensory sections

There was a statistically significant difference between mean scores of the four main CP subtypes in the body position processing section (table 4.6). Z-testing also revealed proportional differences in the body position processing section, whereby the diplegic (93.44%) subtype presented with more difficulties than the hemiplegic (55.10%) subtype. A statistically significant proportional difference was also identified between the dyskinetic (85.71%) subtype and the spastic hemiplegic subtype. The relationship seems to be related to the level of mobility, as well as the limb involvement, whereby the hemiplegic subtype has less severe movement impairments than the dyskinetic and diplegic subtypes.

There were some differences identified between the subtypes in the questions in the SP2. The majority of the questions came from the body position processing section. The differences in these questions relate to the differences in mobility observed between the dyskinetic, diplegic and hemiplegic subtypes, as described above. Additionally, question 12 was identified as being statistically different between the subtypes. It appears that children with ataxia, dyskinesia and hemiplegia have more difficulty finding objects that are obvious to others in comparison to the spastic diplegic subtype.

There were thirteen differences in the questions between the spastic diplegic and hemiplegic subtypes. When examining the specific questions, it appears that the hemiplegic subtype becomes more "*unproductive with background noise",* whereas the diplegic subtype seems "*not to hear*". Both of these behaviours may influence their functioning in the classroom or in noisy environments. Other significant differences between the questions, revealed that the hemiplegic subtype appears to have more "*difficulty finding objects in a busy background"* and they are more *"unaware of temperature"* than children with spastic diplegia. The spastic diplegic subtype presented with more problems in the movement and body position items than the hemiplegic subtype. The higher prevalence of movement difficulties in the spastic diplegic subtype in comparison to the spastic hemiplegic subtype is consistent with the level of severity and mobility of the sample, as most of the diplegic sample in the study had more mobility constraints in comparison to the spastic hemiplegic subtype. One could also assume that body position processing scores are related to the level of GMFCS, whereby the more severely affected the child is the more likely they are to experience body awareness difficulties.

Other observations in the sensory systems were also noted, despite the fact that they were not statistically significant. Auditory processing difficulties occurred more frequently in the dyskinetic subtype (52.38%) and less frequently in the diplegic (37.70%) subtype. Visual processing difficulties were slightly lower in the spastic diplegic subtype (47.54%) in comparison to the other subtypes. Visual modulation difficulties were the highest in the ataxic (66.67%) and the spastic hemiplegic (57.14%) subtypes. Touch processing impairments were more prevalent in the hemiplegic (57.14%) and the ataxic (52.38%) subtypes, and less prevalent in the diplegic (39.34%) and dyskinetic (33.33%) subtypes. Movement disorders occurred the most in the ataxic and dyskinetic (66.67%) subtypes, and the least in the spastic hemiplegic (46.94%) subtype. Oral sensory processing occurred most frequently in the ataxic subtype (57.14%).

The prevalence of each sensory system was different in the CP subtypes. These differences can, in part, be associated to the anatomical lesions associated with the subtypes. However, other factors contributing to the child's specific sensory modulation pattern should also be considered. These differences, albeit clinically significant, were for the most part, not statistically significant. Therefore, the CP subtypes appear to present similarly in the sensory systems. The alternative hypothesis can, therefore, only be accepted for some of the systems.

5.8.3 Behavioural sections

There were no statistically significant differences between the means or the proportions in the behavioural sections (table 4.9); therefore, supporting the null hypothesis. However, there was a difference between the four main CP subtypes, as well as between the spastic hemiplegic and spastic diplegic subtypes in question 77. The hemiplegic subtype seems to have more trouble focusing their attention than the diplegic subtype. The prevalence of attention difficulties in the hemiplegic subtype has been discussed previously.

When looking at the prevalence of difficulties, the social-emotional difficulties were common to all subtypes, whereas the attentional difficulties were only prevalent in the ataxic CP subtype. Children with ataxic CP presented with significant SMD, which might be contributing to their attention difficulties.

For the most part, the alternative hypothesis can be rejected in the behavioural systems.

5.9 OTHER FINDINGS INFLUENCING SENSORY MODULATION IN CHILDREN WITH CEREBRAL PALSY

5.9.1 Movement disorders versus spastic disorders

Damage to the cerebellar, basal ganglia, and thalamic regions in the brain (extrapyramidal) results in movement disorders.[89] Children with spastic types of CP present with increased muscle tone, which is caused by damage to the cortical regions (pyramidal).[89] No studies have examined the sensory modulation differences between these two groups; however, the researcher hypothesised that due to the different areas of the brain involved, there would be differences between these two groups with regards to the SMP in the quadrants, sensory systems, and behavioural sections.

A significant (proportional) difference was found between the seeking prevalence in the movement disorder group (57.14%) in comparison to the spastic disorder group (38.39%). This trend suggests that children with movement CP disorders are more likely to present with seeking behaviours than those with spastic CP disorders. The prevalence of seeking in the ataxic and dyskinetic CP subtypes has been discussed previously.

Figure 4.30 compares the SP2 scores of the two groups. All four quadrants were prevalent in the movement disorder group, which is consistent with the “intense sensory profile”. In contrast, only the avoiding and registration patterns were prevalent in the spastic group, which is consistent with the “mellow until… sensory profile”. Within the sensory sections, the movement group presented with difficulties in all the sections, except for the touch processing section. Only the visual, movement, and body position sections were prevalent in the spastic group. Within the behavioural sections, the attentional and social-emotional sections were areas of concern in the movement disorders, whereas the spastic group only presented with social-emotional difficulties. The higher prevalence of SMD in the quadrants and sensory sections may explain the behavioural challenges observed in the movement disorders.

In general, the movement disorder group appeared to present with more SMD than the spastic disorder group. It is likely that children with movement disorders associated with CP present with more SMD than spastic disorders associated with CP because of the involvement of the basal ganglia, cerebellum and thalamus, which play a significant role in sensory processing and modulation.[151] Further investigation is required with a larger sample size to confirm this hypothesis.

5.9.2 GMFCS levels

The GMFCS level I participants presented with more SMD (three out of four quadrants) than the GMFCS level II (two out of four quadrants) and level III (one out of four quadrants) participants, as highlighted in figure 4.31. Park (2017) reported that there was a correlation between the GMFCS level and the prevalence of SMD, that is, GMFCS level II=III > IV=V.[71] He found that the lower GMFCS levels (II-III) had less SMD than the higher levels (IV-V), whereas this study found that SMD were more prevalent in the lower levels. There are a few reasons for these differences. Firstly, different tests were used in the two studies (SP2 vs SSP). Secondly, the sample sizes in the different GMFCS levels were different in the two studies. There was no level I group in Park's sample because the group only had two participants, and in this study the GMFCS IV and V groups were excluded. Lastly, Park only provided the mean score, and the specific types of SMD experienced by the different GMFCS levels were not revealed. Therefore, direct comparisons could not between the studies.

Proportional z-testing indicated that there were differences in the sensitivity quadrant, specifically between the level I (68.89%) and II (45.76%) groups, and between the level I, and III (34.00%) groups. Albeit not significant, a similar trend was observed in the avoiding quadrant; whereby the level I group had the highest prevalence (62.22%), and level III (48.00%) had the lowest prevalence of avoiding patterns. Therefore, it seems as though the prevalence of low threshold patterns decreases as the GMFCS level increases. These trends suggest that children who are more mobile present with lower threshold patterns. The reason for this trend is unclear. Damage to the CNS has been associated with decreased sensitivity;[50-51,140] therefore, children classified as GMFCS level I may be more sensitive towards sensory input than higher levels because they have less CNS damage.

The level III group had a higher prevalence of registration difficulties in comparison to the level I and II groups. The seeking pattern was more prevalent in the level I and II groups than in the level III group. Despite the fact that these observations were not statistically significant, it appears that as the GMFCS level increases the registration patterns become more prevalent, and the seeking patterns become less prevalent. These trends suggest that children who are less mobile register less sensory information and are less likely to seek additional sensory input. These trends may assist clinicians when treating children with CP on different GMFCS levels. Higher levels may require sensory treatment measures to improve their SUR, whereas children on lower levels may require assistance to cope with SOR.

When comparing the sensory sections, the level I group had difficulty in the visual, touch, and body position processing sections (three out of six sections). The level II group had difficulty in the movement and body position processing sections (two out of six sections). The level III group also had difficulty with movement and body position, as well as with visual processing (three out of six sections). None of the groups presented with auditory and oral sensory processing difficulties.

There was only one statistically significant difference between the sensory systems of the three GMFCS groups, that is, in the body position processing section. When analysing the percentages, the level III group had a higher prevalence in the body position section than both the level I and II groups. These findings provide evidence that proprioceptive processing may be related to the level of GMFCS, and subsequently the level of mobility. Although not significant, movement processing also appears to increase as the GMFCS level increases; indicating that as the motor impairments increase, the vestibular-processing difficulties also increase. The researcher postulates that the more independently the child is in moving, the more they can process and integrate proprioceptive (and vestibular) information. This relationship has significant implications for therapeutic interventions. Therapy interventions based on sensory integration promote movement through three-dimensional space. The use of these interventions may enhance the vestibular-proprioceptive processing in children with CP, which may also positively impact on other motor areas.

Other noteworthy trends occurred in the touch and oral sensory sections. Touch processing and oral sensory processing difficulties appear to decrease with increasing GMFCS levels. The level I group seems to be more sensitive to these types of inputs, which may contribute to the higher prevalence of low threshold patterns in the level I group.

The GMFCS level I participants presented with social-emotional and attentional difficulties (two out of three sections), whereas the GMFCS level II participants only presented with social-emotional difficulties. The GMFCS level III participants had no behavioural difficulties. Therefore, behavioural difficulties appear to be more prevalent in the less severe GMFCS groups. Although not significant, social-emotional difficulties seem to decrease with increasing GMFCS levels. There was a significant difference in the items, *"has temper tantrums", and "expresses feeling like a failure"*; with the level I and II participants having more frequent responses than the level III participants. The more severe GMFCS had a higher prevalence of registration difficulties in this study. Furthermore, the more severe levels tend to have more cognitive deficits. Therefore, children functioning higher on the GMFCS scale may be less aware of their challenges due to their cognitive and/or sensory deficits. Children functioning on GMFCS level I have less severe motor impairments and they may present more typically, which may cause others to have higher expectations of them. They too may have higher expectations of themselves. This study found that the GMFCS level I participants had increased sensory sensitivity, indicating that they may be more likely to notice and compare their impairments to others. This may subsequently cause them emotional distress, which could explain the higher prevalence of social-emotional difficulties in the GMFCS level I group.

In summary, the GMFCS level I group presented with more SMD than the level II and level III groups. This study did not aim to compare the GMFCS levels; however, there does seem to be a correlation between the GMFCS levels and SMP in children with

CP. These findings are consistent with the recent findings in the literature.[71] However, the distribution of the CP subtypes across the GMFCS levels may have influenced the observed patterns. Whether the SMP in the different GMFCS is related to the level of mobility or the subtype distribution is unclear. Further research, using a larger sample and a more homogenous distribution is required to confirm these observed trends.

5.9.3 Age

Sensory modulation patterns are thought to remain relatively consistent over time;[84] however, the severity of these patterns decreases with age.[155] From the sample of CP children, the older group presented with avoiding, registration, visual, movement, body position processing, and social-emotional difficulties (figure 4.32). In contrast, the younger group had a high prevalence of avoiding, sensitivity, and registration patterns.

Although the younger group had less visual processing difficulties, they had more movement and body position processing difficulties. They had slightly less social-emotional difficulties. Although the two groups had similar areas of concern; the younger group had a higher percentage of participants experiencing difficulties in all the areas, except for the visual and social-emotional sections. Furthermore, the younger group had more participants scoring in the “Much More” band in the seeking, avoiding, auditory, visual, touch, movement, oral sensory, conduct, and attentional sections than the older group. These observations suggest that not only did the younger group have more difficulties but that their difficulties were more severe, which is consistent with the literature.[155]

Sensory seeking is considered to be developmentally active, whereby younger children seek more than older children.[82] The standardisation sample in the SP2 manual reported that seeking was more prevalent in the younger group. This difference was statistically significant, with a 6-point difference between the mean scores. In this study, there was a statistically significant difference between the two age bands in the seeking quadrant. On further observation, the seeking pattern was more prevalent in the younger group (49.43%) in comparison to the older group (35.82%), with a 5-point difference between the mean scores. Therefore, in accordance with the findings in the SP2 manual, seeking patterns are more prevalent in younger CP children. Interestingly, a few seeking items were found to be significantly different between the groups. These included: *"watches everyone as they move around the room"*, "*displays need to touch toys, surfaces, or textures", "drapes self over furniture", "shows a strong preference for certain tastes", "seems more active", "struggles to pay attention",* and *"jumps from one activity to the next".* Therefore, these behaviours may be more prevalent in the younger child with CP.

In this sample, younger children were found to have significantly more attentional difficulties than older children. Attention deficits are also reported to decrease with age in children with other neurodevelopmental disorders, such as ADHD.[156]

Although not significant, other trends were also observed in this sample. The prevalence of all the quadrants appears to decrease with age. A study that was done on children with CP using the SSP also found that younger children with spastic diplegia had more difficulties than older children with spastic diplegia; therefore, supporting the findings of this study.[70] This inverse relationship between age and SMP, suggests that SMP may decrease with age in children with CP. The SMP itself may persist, but the severity seems to decrease with age, which may be related to the child maturing or learning to cope or adapt to various sensations. This trend is consistent with clinical observations; however, no literature was found to corroborate this hypothesis. Movement and oral sensory processing difficulties also seem to decrease with age, whereas visual processing difficulties seem to increase with age. Social-emotional difficulties increase with age, which may be related to the maturity of the child, whereby older children are more emotionally aware of their difficulties which may cause them distress. They may feel more withdrawn or rejected in social settings. The clinician should explore the specific social and emotional challenges when interviewing the parents/guardians. Older children can also be interviewed to determine what their difficulties are.

5.9.4 Gender

Both the male and female groups presented with difficulties in the avoiding, registration, visual, movement, body position, as well as the social-emotional sections (figure 4.33). The female group also presented with sensitivity and oral sensory processing difficulties; therefore, falling out in more sections than the male group. The higher prevalence of female participants with dyskinetic CP in comparison to male participants with dyskinetic CP, may have influenced this pattern because the dyskinetic subtype had more SMD in this study.

When considering the percentage of participants scoring out of the norm, males and females were similar in most of the sections; which is consistent with the SP manual, which reports insignificant differences between genders.[82] The males in this study appeared to present with more auditory processing difficulties, which is also consistent with the findings in the manual. Although the auditory processing section was not significantly different, significant p-values were reported in *"struggles to complete tasks when music/TV is on",* and *"is distracted when there is a lot of noise around*. The male participants seemed to have more auditory processing difficulties than the female participants.

5.9.5 Duration of gestation

Registration, avoiding, visual, movement, body position processing, and social-emotional difficulties were more prevalent in the full-term group than in the premature group (figure 4.34). The premature group presented with registration, avoiding, sensitivity, movement, body position processing, conduct, and social-emotional difficulties. Therefore, the premature group experienced more problematic areas in this sample. The full-term group had more participants scoring in the "Much More" band in the registration and body position sections. The premature group had a higher percentage of participants scoring in the "Much More" band in the sensitivity, registration, visual, touch, movement body position, oral sensory, social-emotional and conduct sections. Not only did the premature group have more difficulties, but they also had more severe SMD than the full-term group.

The findings in this study supports the literature, which indicates that premature infants experience more sensory impairments than full-term infants.[147,157] Premature infants miss some of the crucial neurosensory development which occurs in-utero.[147] The clinical picture in prematurity is complicated because several areas of the brain are involved; including the sensory and primary cortex, the connecting pathways between the brainstem nuclei, thalamic relays, and cerebellum, as well as the integration centres.[47,65,157] The involvement of the thalamus and cerebellum, are both considered to be involved in sensory processing, which may provide some explanation for the increased sensory modulation difficulties in the premature group. Furthermore, neuroimaging studies found that the white fibre connections, carrying afferent information, were more involved in children with CP who were born prematurely.[105]

The high prevalence of SMD found in the premature group in this study is similar to the results found in other studies.[147] A recent study, reported SMD in between 39% (>2Sd) and 87% (>1Sd) of children born prematurely.[157] In this study the avoiding and sensitivity patterns were higher in the premature group than in the full-term group; suggesting that children with CP born prematurely have more low threshold SMP than children with CP who are born at full term. Furthermore, z-testing revealed significant differences between the proportions in the registration quadrant. The full-term group (79.41%) had more registration difficulties in comparison to the premature group (60.47%). These findings are consistent with the literature, which indicates that children born prematurely tend to be more over-responsive than under-responsive.[147]

The literature indicated that premature children also experience auditory, tactile and vestibular processing difficulties.[157] In contrast, the findings in this study indicate that auditory processing difficulties are more prevalent in the full-term group, with the prevalence of touch and movement difficulties very similar in both groups.

Statistically significant differences were found in the conduct section between the premature and full-term groups. The premature participants had a significantly higher prevalence of conduct difficulties than children born at full-term. The higher prevalence of SMD, as well as the increased severity of these patterns, may therefore influence their conduct.

The findings in this study contribute to the greater body of knowledge about prematurity, especially in children with CP. It provides evidence to support recent neuroimaging studies, which indicate that periventricular white matter injuries in premature infants result in more sensory impairments, in particular, SOR.[46-47,65] The additional sensory processing difficulties may complicate or change the clinical picture of the child with CP who is born prematurely, and this should be considered when assessing and treating the child.

5.9.6 Birth weight

The NBW group presented with avoiding and registration patterns of processing, as well as visual, movement, body position processing and social-emotional difficulties, which was similar to the full-term group (figure 4.25). The LNBW group presented with difficulties in all areas except for the seeking, visual, and touch sections. Therefore, the LNBW group experienced more sensory modulation difficulties than the NBW group; as reported in the literature.[158] No significant differences occurred between the two groups.

In summary, children born below 2500g are more likely to have sensory modulation difficulties than children born more than 2500g.

5.10 SUMMARY OF DISCUSSION

This chapter discussed the results obtained from the SP2 in children with CP, and the main subtypes. Other contextual factors were also discussed. Interpretations of the results were provided based on the researcher's clinical reasoning and expertise, and where available, supporting literature. The next chapter will present concluding remarks, as well as discuss the factors which positively and negatively affected the study. The implications of the study will also be highlighted, and the researcher will make recommendations for future research.

CHAPTER 6
CONCLUSION

6.1 INTRODUCTION

The concluding chapter will provide an overview of the research question and findings, to re-orientate the reader. The researcher will then critically evaluate the study, with regards to the positive and negative aspects of the representation, inclusion and exclusion criteria, language, and measurement tools. Thereafter, the implications will be discussed, as well as the recommendations for further research. Lastly, a summary of the chapter will be provided.

6.2 OVERVIEW OF RESEARCH QUESTION AND FINDINGS

The purpose of this study was to describe and compare the SMP prevalent in children with CP, as well as in the different types of CP. Although children with CP present with SMD, there is a disparity between clinical practice and the available empirical evidence in the literature. Studies have confirmed the presence of SMD in children with CP;[39,66-67,70] however, no differences were identified between the subtypes. The uncertainty in the literature led to the research question: Do children with different types of cerebral palsy, i.e. ataxic, dyskinetic, and spastic (hemiplegic, diplegic, and quadriplegic) present with different patterns of sensory modulation?

Inferential analysis revealed statistically significant differences between the proportions of some of the subtypes in the sensitivity ($p=0.040$) quadrant (ataxia>spastic diplegia), and the registration ($p=0.028$) quadrant (spastic diplegic>spastic hemiplegic); therefore, providing some support for the alternative hypothesis. Descriptive analysis revealed that the registration and avoiding patterns were prevalent in all the subtypes; whereas the seeking pattern was more likely to occur in the ataxic and dyskinetic subtypes, than the spastic subtypes.

The sensory systems and behavioural responses influence the SMP; therefore, they were also analysed. There was a statistically significant difference between the means (p=0.000) and proportions (p=0.000) of the four main subtypes in the body position processing section. Other proportional differences were also observed between the subtypes in the body position processing section (dyskinetic>spastic hemiplegic; spastic diplegic>spastic hemiplegic). There was, therefore, tentative support for the alternative hypothesis in the sensory systems. There were no statistically significant differences between the behavioural responses; therefore, providing support for the null hypothesis.

Although only a few statistically significant differences were observed between the subtypes, many clinically significant were identified in the study. These findings will assist with the assessment and treatment of SMD in children with different types of CP. This study provides some support for the hypotheses made in the literature, in particular by Blanche and Nakasuji (2001). Furthermore, this study found that all the subtypes of CP have substantial SMD in comparison to the normal population within the four sensory quadrants, and that these quadrants correlate strongly with each other. The study also found that GMFCS levels, age, and prematurity contribute to SMD and SMP in children with CP.

6.3 CRITICAL EVALUATION OF THE STUDY

6.3.1 Representation, sample size and generalisability

The CP proportions in this study were similar to the proportions identified in the literature, which indicated that approximately 70-80% are from the spastic subtype, 10-20% are from the dyskinetic subtype, and 5-10% are from the ataxic subtype. Although there were more participants with spastic diplegia and less participants with spastic quadriplegia in this study, this is related to the exclusion of GMFCS levels IV-V. This study was representative of the SES, cultural and language diversity in SA.

Due to time and financial constraints, a convenience sampling method was used, which affects the generalisability of the results.[142] The researcher assumed that because of the large sample size (n=154), the results of the CP sample could be generalised to the greater CP population (GMFCS levels I-III), albeit that this should be done cautiously. The ataxic (n=21) and dyskinetic (n=21) sample sizes were smaller than the spastic diplegic (n=61) and hemiplegic (n=49) sample sizes, which may have influenced the magnitude of the correlations found in the study, as well as the external validity. Therefore, clinicians should use their discretion when interpreting the results related to the CP subtypes, especially in these two groups.

6.3.2 Methodology

Originally the researcher planned on sending out two research information packs to the parents/guardians. The first pack contained the consent form and the second pack contained the SP2. Due to time constraints, the researcher decided to send all the forms together. The contents of the first pack was separated from the second pack, to ensure that parents/guardians only completed the SP2 once they had read the informed consent form. This method made it easier for the researcher to collect the forms. It also simplified the process for the parents/guardians. When the parents/guardians were contacted in phase three, they were again made aware that their participation was voluntary and that they could withdraw at any time. In hindsight, this method might have been better as it allowed the parents/guardians to complete all the forms together and prevented the loss of documents in the data collection process.

6.3.3 Inclusion and exclusion criteria

The study chose to include children with associated impairments as these were assumed to be part of the CP condition, as highlighted in the definition of CP. Children with severe cases were not included, as the literature indicated that these children already have sensory modulation difficulties. The inclusion of children with associated impairments may have influenced the results.

The researcher chose to omit participants functioning on GMFCS levels IV-V as they do not walk or only walk in a limited capacity. Literature also indicated that the GMFCS levels IV-V had more severe SMD.[71] The exclusion of these levels may have influenced the results with regards to providing an overall clinical picture of SMP in children with CP.

The choreoathetotic and dystonic CP subtypes were combined to increase the statistical power of the group. This may have obscured the unique differences between these subtypes.

An assessment was not done on each participant. The researcher relied on the school-based occupational therapists, information in the participant's files, and parent questionnaires to include or exclude participants. Several "checks" were put in place, whereby participants could be excluded if they were unsuitable based on the inclusion/exclusion criteria. Using a variety of methods improved the accuracy of the inclusion of the participants into the study and eliminated the potential for researcher bias.

6.3.4 Language constraints

There were several primary and secondary languages reported in the background questionnaire, which reflects the diversity of languages in SA. English was said to be the primary home language in 14.94% of participants, and the second language in 42.86% of participants, with the majority of participants speaking an African language. Despite the measures taken by the researcher, such as excluding those who did not speak English, as well as communicating with the parents/guardians during the study; language might have influenced the understanding of the questionnaire. Some of the terminology in the questionnaire might not have been well known to the average respondent, such as "seems to tune me out" and "drapes self over furniture". Other terms were complicated, such as *"seems oblivious"* and *"competing backgrounds*".

Twelve out of the 86 questions (13.95%) received a zero score in 5% or more of the CP sample. The questions were: question nine, *"prefers to play or work in low lighting"* and question 10, *"prefers bright colours or patterns for clothing"* from the visual section; question 32, *"looks for opportunities to fall with no regard for own safety (for example, falls down on purpose)"* from the movement section; question 41, *"drapes self over furniture or on other people"* and question 42, *"needs heavy blankets to sleep"* from the body position section; question 48, *"smells non-food objects"* and question 52, *"bites tongue or lips more than same-aged children"* from the oral sensory section; question 53, *"seems accident prone"*; question 55, *"takes excessive risks (for example,* *climbs high into a tree, jumps off tall furniture) that compromise own safety"*; question 60, *"appears to enjoy falling"; and question* 61 *"resists eye contact from me or others"* from the conduct section; and question 84, *"gets lost easily"* from the attentional section. The higher prevalence of zero scores in these questions may indicate that the parents/guardians did not understand these questions. Alternatively, these questions may have not been relevant to the CP sample.

The SP2 is not available in SA languages. Standardising the questionnaire in more than one SA language was not possible because this would have involved another study to measure the validity and reliability of the translated questionnaire. However, 61.7% of mothers, who were the predominant respondents in the study, had a Matric or tertiary education, which would have supported their ability to complete the questionnaire. Moreover, several measures were put in place by the researcher to ensure that the SP2 was understandable. These included: excluding those who did not understand the questionnaire, including a pilot phase to ensure that the participants would understand the questionnaire, providing a description of sensory modulation and how to complete the questionnaire, and contacting the parents/guardians after the study to clarify any questions or concerns. The pilot phase indicated that the SP2 was understandable to the majority of participants.

6.3.5 Measurement tools

A weakness with regards to the measurement tool was that it is a parent/caregiver-based questionnaire, which poses a risk of respondent bias or error. Furthermore, the researcher found that the use of the words "always" and "never" had an emotional effect on the respondents. Telephonic conversations with the respondents revealed that these words tended to bring up other emotional difficulties that they were going through at the time. For example, "my child is not as severe", or "I also struggle with this", causing them to score their child's responses/behaviours more typically. Having a child with a disability is very emotionally taxing on caregivers, and their emotional status may have influenced their scoring. However, no standardised, objective, clinician-administered tool to assess sensory modulation was available for use at the time of the study.

The researcher conducted a pilot phase (n=30) before the main study. These participants were known to the researcher, as they were from the school where the researcher works. The results of these participants were analysed by the researcher, as well as by another occupational therapist who also knew the participants. These results were consistent with the clinical observations of the children; for example, a child with known tactile difficulties presented with high touch processing scores, and a child with no known SMD presented with typical results. Albeit, subjective and not statistically examined, it did provide some support that the SP was able to measure sensory modulation difficulties in children with CP. Therefore, the researcher assumed that the SP2 was a valid tool to measure sensory modulation in children with CP.

A significant challenge in this study was that the SP2 gave the respondent the option of selecting DNA, which is a new inclusion in the SP2. As stated in the manual, this option is for cases where a question is not relevant to the child. This explanation was quite vague, and therefore the researcher assumed that it applied to children who were unable to perform a particular task, or when the parent/caregiver had never witnessed the behaviour. Although there was an explanation on the front page of the SP2, the researcher also explained when to use the DNA option in the handout for the parents/guardians. Despite this, there was some confusion regarding the difference between "almost never" and the DNA option. Common remarks were: "I did not know the difference between does not apply and never", "my child is less severe than other children with CP, so it does not apply", or "my child never does that, so it does not apply". The respondents with higher levels of education also struggled with the DNA option, and therefore it is not only related to the level of education or language deficits. Moreover, this difficulty also arises in a private practice setting.

When contacting the parents/guardians, the researcher provided further explanation in the cases where the DNA was frequently selected. The manual advises the clinician to provide clarity in these cases. The researcher only changed the original responses if the parent/guardian understood the change and gave verbal consent to do so. In the majority of cases, the changed response was from DNA to "almost never", a 1-point difference, which had a minimal effect on the cut score or band. A few participants changed from the "Just Like" to the "More Than" band, with more changing from the "Less Than" to the "Just Like" band. If anything, by changing the scores, the researcher increased the proportion of participants scoring in the “Just Like” band. By clarifying the respondent’s intentions, the researcher aimed to improve the accuracy of the results.

Another aspect, which requires discussion, is the applicability of the SP2 for children with CP. The standardisation sample of the SP2 did not include children with CP. The majority of SI-based studies exclude this group because SI theorists do not promote the use of SI assessments and treatments in children with CP. They believe that the damage to the CNS causes the underlying SMD in CP, as opposed to the subcortical structures.[2] However, there is growing support indicating that CNS damage is not the only cause of the sensory impairments observed in CP, but that the ascending tracts may also be involved.[46-50] Although the SP2 assesses sensory modulation in TD children, it is frequently used to screen for other neurodevelopmental disorders, such as ASD and ADHD. Several questions in the SP2 correspond with behaviours commonly observed in children with these conditions. A few studies have used the SP in the CP population and found that it was a useful tool.[37,68-71] The researcher agrees that some questions may not be relevant to children with CP, and that in some cases the high scores may reflect the child’s physical impairments rather than SMD. However, some children may have scored low in a section, but present with SMD. Therefore, when interpreting these questions or sections, the clinician’s discretion should be applied. Nevertheless, the presence of physical limitations does not exclude the presence of SMD alone.

The results were not able to identify clear and statistically significant differences in all the sensory sections between the main CP subtypes. According to sensory modulation theories, each person has a unique sensory profile, depending on various internal and external factors.[32,82] The differences may have been less significant than anticipated because children with CP may also have individual contributing factors which impact on their sensory profile, such as different sensory experiences, genetics, environment, personality, and sensorimotor limitations. Thus, clinicians should always interpret the results carefully, and corroborate their findings with other measures.

Despite the limitations with regards to the measurement tool, the SP2 was found to be a useful measure of SMD in children with CP.

6.4 IMPLICATIONS OF THE STUDY

The presence of SMD in children with CP has been reported consistently over the last decade.[37,68-71] Despite this, sensory modulation does not consistently form part of the assessment of the child with CP.[73] The sample size in this study was larger and included all the subtypes of CP, which was recommended by similar studies. In doing so, it contributed substantial evidence supporting the presence of SMD in children with CP. The high prevalence reported in this study justifies the use of sensory modulation assessments, including the SP2, along with other standardised sensory-based assessments in the child with CP. In the same way, the findings advocate for the use of specific sensory-based strategies in the treatment of the child with CP based on the clinician's assessment findings.

Additionally, this study contributed meaningful data to support the hypothesis that different types of CP present with different types of SMD within the quadrant and sensory sections. Although different subtypes may present with different SMP, different sensory systems may be involved. Each child may have unique differences, which are influenced by their own internal and external factors. Therefore, although the clinician may anticipate some differences between the subtypes, these assumptions should not bias the assessment of the child. The assessment should be holistic and consider all the contextual and functional aspects which may be contributing to the child's observed patterns. Recommendations or adaptations for the home and school environments should be individualised to the child's sensory needs to allow the child to function more optimally.

When assessing a child with CP, it is imperative to consider both the motor and sensory modulation aspects. The fact that the damage associated with CP may cause the behaviours reported in the SP2, does not make them irrelevant. The SP2 allows the clinician to gain insight into how these difficulties may be affecting the child's functional performance at home. The findings of the SP2 should always be corroborated by clinical observations and parent interviews.

This study found that other factors also contribute to the sensory modulation in children with CP. Firstly, movement disorders associated with CP appear to have more SMD than spastic CP disorders. Secondly, children classified as functioning on GMFCS level I are likely to present with more SMD, in particular, SOR, than those classified as functioning on GMFCS level III; however, vestibular-proprioceptive and registration difficulties are more prevalent in the more severe levels. Thirdly, sensory seeking behaviours are more prevalent in the younger child with CP than the older child. Lastly, the findings in this study provide additional support that LBW and prematurity contribute to increased SMD, including in children with CP. These factors should form part of the holistic interpretation of the results.

The findings of this study extend to other professions who work with children with CP, such as physiotherapists and speech therapists. Occupational therapists should communicate the child's sensory difficulties to other team members as this may also impact on their treatment. They can incorporate this knowledge into their treatment and activity selection.

6.5 RECOMMENDATIONS FOR FURTHER RESEARCH

The findings of this study contributed predominantly clinically significant information. There were only a few statistically significant differences reported between the subtypes. Since a considerable proportion of participants had difficulties, the sample size may not have been large enough to detect the subtle differences between the subtypes. Further research, using a larger sample size, which includes all the subtypes in a more equal distribution, may reveal more significant differences between the subtypes. This study did not differentiate between the choreoathetotic and dystonic CP subtypes. These subtypes should be examined to compare their patterns. Furthermore, this study chose to focus on only the GMFCS I-III groups. Other studies should examine SMP in the GMFCS IV and V groups. This study did not aim to explore the differences between spastic diplegia caused by HIV and HIV encephalopathy, and typical spastic diplegia. Researchers have argued that their motor impairments differ.[146] A follow up study could be done to examine the differences between the children with CP and HIV, and children with CP and without HIV to determine whether there are any significant differences in their SMP.

The SP2 was not standardised in the SA population. Clinicians often rely on assessment measures that have been standardised in developed countries, due to the lack of equivalent and culturally appropriate tools in SA. Considering the language constraints of the SP2 for the SA population, the SP2 should be translated and validated into SA languages. In doing so, this will improve the accessibility of the questionnaire for the respondents, as well as the reliability of the assessment for researchers and clinicians.

Although the SP2 was a useful tool to identify SMD in children with CP, it was not developed for children with CP. Researchers should develop an assessment tool that can accurately and discretely measure the unique sensory difficulties prevalent in children with CP, especially within the sensory systems. This will alleviate some of the confusion in the motor-based questions.

At the time of the study, the SPS assessment tool had not been standardised and was therefore not available for use. This assessment tool utilises both caregiver-based and examiner-based tools to assess sensory modulation in all the sensory systems. There are often discrepancies between what the therapist observes and what the caregiver reports. A study using an examiner-administered tool is recommended to compare the results to the SP2, which is parent/caregiver-administered. A study of this nature will be useful to determine whether there a consistent trend or pattern in the CP subtypes, which will improve the validity of the data.

Lastly, having confirmed the presence of SMD in children with CP, it is recommended that researchers focus on investigating the efficacy of sensory integration or sensory-based strategies as a treatment approach for SMD in children with CP.

6.6 SUMMARY OF CONCLUSION

This chapter provided an overview of the research question and results. The researcher critically evaluated the factors which positively and negatively influenced the outcome of the study. The implications of the study, as well as recommendations for other researchers, were also highlighted in this chapter.

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Appendix A: Sensory Profile 2

Caregiver Questionnaire

3:0 to 14:11 years

CHILD

CHILD

SENSORY PROFILE 2

Winnie Dunn, PhD, OTR, FAOTA

FOR OFFICE USE ONLY

Calculation of Child's Age

	Year	Month	Day
Test Date			
Birth Date			
Age			

Child's First Name: ____________ Child's Middle Name: ____________

Child's Last Name: ____________ ID Number: ____________

Child's Preferred Name (if different from above): ____________

Gender: ☐Male ☐Female Birth Date: ____/____/____ Test Date: ____/____/____

Examiner/Service Provider's Name: ____________

Examiner/Service Provider's Profession: ____________

Completed by/Caregiver's Name: ____________

Caregiver's Relationship to Child: ____________

Name of School/Daycare Center: ____________

School Grade/Level: ____________

In what order was your child born in relation to siblings (for example, 1st child, 3rd child, etc.)?
☐Only Child ☐1st ☐2nd ☐3rd ☐4th ☐5th ☐ Other____________

Have there been more than three children between the ages of birth through 18 years living in your household during the past 12 months? ☐Yes ☐No

INSTRUCTIONS

The pages that follow contain statements that describe how children may act. Please read each phrase and select the option that best describes how often your child shows these behaviors. *Please mark one option for every statement.*

Use these guidelines to mark your responses:

When presented with the opportunity, my child...

Almost Always	responds in this manner **Almost Always** (90% or more of the time).
Frequently	responds in this manner **Frequently** (75% of the time).
Half the Time	responds in this manner **Half the Time** (50% of the time).
Occasionally	responds in this manner **Occasionally** (25% of the time).
Almost Never	responds in this manner **Almost Never** (10% or less of the time).
Does Not Apply	If you are unable to answer because you have not observed the behavior or believe that it does not apply to your child, please check **Does Not Apply.**

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1 2 3 4 5 6 7 8 9 10 11 12 A B C D E

Product Number 0158700058

Appendix B: Sensory Profile 2 quadrant calculation sheet

FOR OFFICE USE ONLY

CHILD SENSORY PROFILE 2

SCORE SUMMARY

Quadrant Grid

Instructions

Please read carefully the detailed hand-scoring instructions in chapter 4 of the Sensory Profile 2 User's Manual. Transfer the item raw scores from the Caregiver Questionnaire. Add each column of raw scores to get the Quadrant Raw Score Totals.

Seeking/Seeker

Item	Raw Score
14	
21	
22	
25	
27	
28	
30	
31	
32	
41	
48	
49	
50	
51	
55	
56	
60	
82	
83	
Seeking Quadrant Raw Score Total	

Avoiding/Avoider

Item	Raw Score
1	
2	
5	
15	
18	
58	
59	
61	
63	
64	
65	
66	
67	
68	
70	
71	
72	
74	
75	
81	
Avoiding Quadrant Raw Score Total	

Sensitivity/Sensor

Item	Raw Score
3	
4	
6	
7	
9	
13	
16	
19	
20	
44	
45	
46	
47	
52	
69	
73	
77	
78	
84	
Sensitivity Quadrant Raw Score Total	

Registration/Bystander

Item	Raw Score
8	
12	
23	
24	
26	
33	
34	
35	
36	
37	
38	
39	
40	
53	
54	
57	
62	
76	
79	
80	
85	
86	
Registration Quadrant Raw Score Total	

Appendix C: Sensory Profile 2 summary score sheet

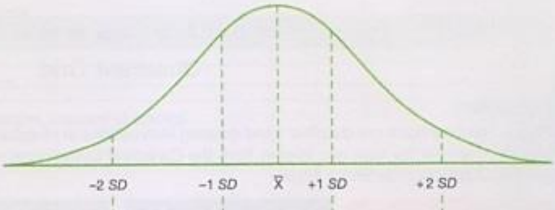
Summary Scores

Instructions

Transfer each Quadrant Raw Score Total from the Quadrant grids to the corresponding Quadrant Raw Score Total box. Then, transfer the section Raw Score Totals from the Caregiver Questionnaire to the corresponding Raw Score Total box. Plot these totals by marking an X in the appropriate classification column (e.g., Less Than Others, More Than Others, Just Like the Majority of Others).

The Normal Curve and Sensory Profile 2 Classification System

Scores one standard deviation or more from the mean are expressed as More Than Others or Less Than Others, respectively. Scores two standard deviations or more from the mean are expressed as Much More Than Others or Much Less Than Others, respectively.



		Raw Score Total	Percentile Range[a]	◄ Less Than Others: Much Less Than Others	Less Than Others	Just Like the Majority of Others	More Than Others ►: More Than Others	Much More Than Others
Quadrants	Seeking/Seeker	/95		0-------6	7-------19	20-------47	48-------60	61-------95
	Avoiding/Avoider	/100		0-------7	8-------20	21-------46	47-------59	60-------100
	Sensitivity/Sensor	/95		0-------6	7-------17	18-------42	43-------53	54-------95
	Registration/Bystander	/110		0-------6	7-------18	19-------43	44-------55	56-------110
Sensory Sections	Auditory	/40		0-------2	3-------9	10-------24	25-------31	32-------40
	Visual	/30		0-------4	5-------8	9-------17	18-------21	22-------30
	Touch	/55		0	1-------7	8-------21	22-------28	29-------55
	Movement	/40		0-------1	2-------6	7-------18	19-------24	25-------40
	Body Position	/40		0	1-------4	5-------15	16-------19	20-------40
	Oral	/50		**	0-------7	8-------24	25-------32	33-------50
Behavioral Sections	Conduct	/45		0-------1	2-------8	9-------22	23-------29	30-------45
	Social Emotional	/70		0-------2	3-------12	13-------31	32-------41	42-------70
	Attentional	/50		0	1-------8	9-------24	25-------31	32-------50

[a] For percentile ranges, see Appendix A in the Sensory Profile 2 User's Manual.
** No scores are available for this range.

Quadrant Definitions	
Seeking/Seeker	The degree to which a child *obtains* sensory input. A child with a Much More Than Others score in this pattern seeks sensory input at a higher rate than others.
Avoiding/Avoider	The degree to which a child is *bothered* by sensory input. A child with a Much More Than Others score in this pattern moves away from sensory input at a higher rate than others.
Sensitivity/Sensor	The degree to which a child *detects* sensory input. A child with a Much More Than Others score in this pattern notices sensory input at a higher rate than others.
Registration/Bystander	The degree to which a child *misses* sensory input. A child with a Much More Than Others score in this pattern misses sensory input at a higher rate than others.

8 CHILD Sensory Profile 2

Appendix D: Participation letter and informed consent form for school principals

Postnet Suite 108
Private Bag X1037
Germiston
1400

June 2017

XXXXXXXX
XXXXXXXX
XXXXXXXX
XXXXXXXX
XXXXXXXX

Attention: Principal of XXXXXXXX School

RE: PERMISSION TO CONDUCT A STUDY AT XXXXXXXX SCHOOL

Dear Sir/Madam,

This letter serves to request permission to conduct a study at your school.

Purpose of the study

The researcher is in the process of completing her Master of Occupational Therapy degree at the University of Pretoria. The title of the study is: "**Sensory modulation patterns in children with Cerebral Palsy: A comparative-descriptive study".**

Sensory modulation refers to how we register and respond to different types of information coming from the different senses in our body i.e. touch, smell, taste, movement, hearing and vision. We know from research that if children have a problem with registering and/or responding to sensations they may behave differently to other children. They might constantly be on the go, want to spin, climb on furniture or fidget with objects. They could also be very sensitive to textures, sounds, or seem fearful of heights or moving. These difficulties may affect their learning, behaviour, attention, social interactions, emotional functioning, as well as their participation in daily activities.

Studies show that children with Cerebral Palsy (CP) often present with sensory modulation difficulties. This study will assist me in understanding the types of sensory modulation difficulties that children with CP might have, and the effect on their behaviour and learning.

The study will include 150 learners from five special needs (LSEN) schools in Johannesburg, including XXXXXXXX School. These schools have been selected to participate in the study because they cater for children with Cerebral Palsy with specific learning disabilities, mild intellectual or moderate intellectual impairments.

What are the procedures involved for your school?
The participants in the study will include the parents/guardians of the learners identified. The parents/guardians will be required to complete a parent background questionnaire, as well as the Sensory Profile 2, a standardised questionnaire which measures sensory modulation.

The study will occur in three phases from August to September 2017.

Phase 1: Candidate selection
The Occupational Therapist (OT) and/or Physiotherapist (PT) at the school will be asked to identify learners with CP who of fulfil the inclusion and exclusion criteria from the class lists. The PT/OT will need to classify the learners according to their subtype of CP (based on the SCPE classification tree), as well as their GMFCS level. Refer to appendix A and B.

Inclusion criteria:
- Diagnosed with CP before the age of 2 years old
- GMFCS levels I, II, or III
- Aged between 5.0-14.11 years old at the time of the study
- From any socio-economic, ethnic race, gender, religious or cultural group.
- Receiving Occupational Therapy intervention at school
- The parents/guardians of the eligible learners need to complete the informed consent forms, as well as a parent questionnaire. They need to be literate and be able to understand English to be included in the study.

Exclusion criteria:
- Severe or profound intellectual disability
- GMFCS levels IV and V
- Uncontrolled Epilepsy
- Diagnosed with a comorbid disorder i.e. Autism, ADHD or any genetic syndrome
- Diagnosed with an acquired brain injury such as near drowning, traumatic brain injury or meningitis after the age of 2 years old.

Phase 2: Obtaining consent forms
The researcher will drop off envelopes containing the informed consent forms, information leaflets on sensory modulation and parent questionnaires at the school. A list will be given with all the learners identified, based on the inclusion/exclusion criteria. The OT/PT will need to ensure that the envelopes are sent home with the learners in their message books; and collected when they are returned. The consent forms should be returned within 2 weeks. The researcher will collect all returned envelopes on a specified date.

Phase 3: Completion of the Sensory Profile 2
The researcher will deliver the Sensory Profile 2 questionnaire, a leaflet explaining how to complete the questionnaire as well as a leaflet explaining sensory modulation in envelopes to the school. These will be given to the learners whose parents/guardians provided consent to participate in the study. A list will be given with all the learners identified. The OT/PT will need to ensure that the envelopes are sent home with the learners in their message books. The parents will need to complete the Sensory Profile 2 questionnaire, which should take them about 15 to 20 minutes to complete. The completed questionnaire will then be sealed in the envelope and

returned to the school. The OT/PT will need to collect the envelopes when they are returned. The researcher will make arrangements with the school to collect the sealed envelopes. This will occur outside of teaching time, and thus it will not interfere with the school programme.

What are the risks?
There are no risks involved.

Are there any benefits?
The study will have numerous benefits. Firstly, it will allow Occupational Therapists to better assess and treat these difficulties, as well as make suitable adaptions to the classroom to allow these children cope better which will optimise their learning. Secondly parents/guardians will receive short reports based on their child's results. These reports will be made available to the school therapist provided the parents have given consent to do so. The report will include recommendations to allow parents, as well as the therapists and teachers to accommodate for the child's needs at home and school. This will benefit the quality of therapy and ultimately the children. The results of the study will be published and thus can be applied to other schools in South Africa.

May participants withdraw from the study?
Parents/guardians, as well as participating schools will be allowed to withdraw from the study at any time without having to give a reason. The study is completely voluntary and not taking part in it, or withdrawing from it, carries no consequences.

What about confidentiality?
All data obtained will be coded to maintain confidentiality. The identity of the parents/guardians, the learners, as well as the school will be protected at all times and will not be published or made public at any time. The researcher will be the only person to have access to the name list and the codes used. The forms will be kept locked in a cabinet at the University of Pretoria.

Has the study received ethical approval?
The study has been approved by the Department of Education (see appendix C). This proposal is currently under review by the Faculty of Health Sciences Research Ethics Committee, University of Pretoria, telephone numbers 012 356 3084 / 012 356 3085. The study will only commence once written approval has been granted by that committee.

Please feel free to contact me should you have any concerns or queries regarding this study. You are welcome to have a copy of the research proposal which provides detailed information on the theoretical background of the study as well as on the statistical information for the study.

Kind regards,

Shánna Louwrens
Occupational Therapist
shanna.louwrens@gmail.com
0825639806

CONSENT TO PARTICIPATE IN THIS STUDY

I have read or had read to me in a language that I understand the above information before signing this consent form. I understand that my consent is provisional, pending approval from the Faculty of Health Sciences Research Ethics Committee, University of Pretoria

The content and meaning of this information has been explained to me. I have been given an opportunity to ask questions and am satisfied that they have been answered satisfactorily. I understand that if I do not participate there will be no consequences. I hereby volunteer to take part in this study.

____

Principal's name

________________________ ________________________

Principal's signature Date

____

Witnesses' name

________________________ ________________________

Witnesses' signature Date

____

Researcher's name

________________________ ________________________

Researcher's signature Date

Appendix E: Participation letter and informed consent form for School Governing Body

Postnet Suite 108
Private Bag X1037
Germiston
1400

June 2017

XXXXXXXX
XXXXXXXX
XXXXXXXX
XXXXXXXX
XXXXXXXX

Attention: School Governing Body of XXXXXXXX School

RE: PERMISSION TO CONDUCT A STUDY AT XXXXXXXX SCHOOL

Dear Sir/Madam,

This letter serves to request permission to conduct a study at your school.

Purpose of the study
The researcher is in the process of completing her Master of Occupational Therapy degree at the University of Pretoria. The title of the study is: "**Sensory modulation patterns in children with Cerebral Palsy: A comparative-descriptive study".**

Sensory modulation refers to how we register and respond to different types of information coming from the different senses in our body i.e. touch, smell, taste, movement, hearing and vision. We know from research that if children have a problem with registering and/or responding to sensations they may behave differently to other children. They might constantly be on the go, want to spin, climb on furniture or fidget with objects. They could also be very sensitive to textures, sounds, or seem fearful of heights or moving. These difficulties may affect their learning, behaviour, attention, social interactions, emotional functioning, as well as their participation in daily activities.

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The study will include 150 learners from five special needs (LSEN) schools in Johannesburg, including XXXXXXXX School. These schools have been selected to participate in the study because they cater for children with Cerebral Palsy with specific learning disabilities, mild intellectual or moderate intellectual impairments.

What are the procedures involved for your school?
The participants in the study will include the parents/guardians of the learners identified. The parents/guardians will be required to complete a parent background questionnaire, as well as the Sensory Profile 2, a standardised questionnaire which measures sensory modulation.

The study will occur in three phases from August to September 2017.

Phase 1: Candidate selection
The Occupational Therapist (OT) and/or Physiotherapist (PT) at the school will be asked to identify learners with CP who of fulfil the inclusion and exclusion criteria from the class lists. The PT/OT will need to classify the learners according to their subtype of CP (based on the SCPE classification tree), as well as their GMFCS level. Refer to appendix A and B.

Inclusion criteria:

- Diagnosed with CP before the age of 2 years old
- GMFCS levels I, II, or III
- Aged between 5.0-14.11 years old at the time of the study
- From any socio-economic, ethnic race, gender, religious or cultural group.
- Receiving Occupational Therapy intervention at school
- The parents/guardians of the eligible learners need to complete the informed consent forms, as well as a parent questionnaire. They need to be literate and be able to understand English to be included in the study.

Exclusion criteria:

- Severe or profound intellectual disability
- GMFCS levels IV and V
- Uncontrolled Epilepsy
- Diagnosed with a comorbid disorder i.e. Autism, ADHD or any genetic syndrome
- Diagnosed with an acquired brain injury such as near drowning, traumatic brain injury or meningitis after the age of 2 years old.

Phase 2: Obtaining consent forms
The researcher will drop off envelopes containing the informed consent forms, information leaflets on sensory modulation and parent questionnaires at the school. A list will be given with all the learners identified, based on the inclusion/exclusion criteria. The OT/PT will need to ensure that the envelopes are sent home with the learners in their message books; and collected when they are returned. The consent forms should be returned within 2 weeks. The researcher will collect all returned envelopes on a specified date.

Phase 3: Completion of the Sensory Profile 2
The researcher will deliver the Sensory Profile 2 questionnaire, a leaflet explaining how to complete the questionnaire as well as a leaflet explaining sensory modulation in envelopes to the school. These will be given to the learners whose parents/guardians provided consent to participate in the study. A list will be given with all the learners identified. The OT/PT will need to ensure that the envelopes are sent home with the learners in their message books. The parents will need to complete the Sensory Profile 2 questionnaire, which should take them about 15 to 20 minutes to complete. The completed questionnaire will then be sealed in the envelope and

returned to the school. The OT/PT will need to collect the envelopes when they are returned. The researcher will make arrangements with the school to collect the sealed envelopes. This will occur outside of teaching time, and thus it will not interfere with the school programme.

What are the risks?
There are no risks involved.

Are there any benefits?
The study will have numerous benefits. Firstly, it will allow Occupational Therapists to better assess and treat these difficulties, as well as make suitable adaptions to the classroom to allow these children cope better which will optimise their learning. Secondly parents/guardians will receive short reports based on their child's results. These reports will be made available to the school therapist provided the parents have given consent to do so. The report will include recommendations to allow parents, as well as the therapists and teachers to accommodate for the child's needs at home and school. This will benefit the quality of therapy and ultimately the children. The results of the study will be published and thus can be applied to other schools in South Africa.

May participants withdraw from the study?
Parents/guardians, as well as participating schools will be allowed to withdraw from the study at any time without having to give a reason. The study is completely voluntary and not taking part in it, or withdrawing from it, carries no consequences.

What about confidentiality?
All data obtained will be coded to maintain confidentiality. The identity of the parents/guardians, the learners, as well as the school will be protected at all times and will not be published or made public at any time. The researcher will be the only person to have access to the name list and the codes used. The forms will be kept locked in a cabinet at the University of Pretoria.

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Kind regards,

Shánna Louwrens
Occupational Therapist
shanna.louwrens@gmail.com
0825639806

CONSENT TO PARTICIPATE IN THIS STUDY

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____

Chairperson's Name

________________________ ________________________

Chairperson's Signature Date

____

Witnesses' name

________________________ ________________________

Witnesses' signature Date

____

Researcher's name

________________________ ________________________

Researcher's signature Date

Appendix F: Participation letter and informed consent form for therapist(s)

Postnet Suite 108
Private Bag X1037
Germiston
1400

June 2017

XXXXXXXX
XXXXXXXX
XXXXXXXX
XXXXXXXX
XXXXXXXX

Attention: Occupational and/or Physiotherapy Department

RE: PERMISSION TO CONDUCT A STUDY AT XXXXXXXX SCHOOL

Dear Sir/Madam,

This letter serves to request permission to conduct a study at your school.

Purpose of the study
The researcher is in the process of completing her Master of Occupational Therapy degree at the University of Pretoria. The title of the study is: "**Sensory modulation patterns in children with Cerebral Palsy: A comparative-descriptive study".**

Sensory modulation refers to how we register and respond to different types of information coming from the different senses in our body i.e. touch, smell, taste, movement, hearing and vision. We know from research that if children have a problem with registering and/or responding to sensations they may behave differently to other children. They might constantly be on the go, want to spin, climb on furniture or fidget with objects. They could also be very sensitive to textures, sounds, or seem fearful of heights or moving. These difficulties may affect their learning, behaviour, attention, social interactions, emotional functioning, as well as their participation in daily activities.

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What are the procedures involved for your school?
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The study will occur in three phases from August to September 2017.

Phase 1: Candidate selection
The Occupational Therapist (OT) and/or Physiotherapist (PT) at the school will be asked to identify learners with CP who of fulfil the inclusion and exclusion criteria from the class lists. The PT/OT will need to classify the learners according to their subtype of CP (based on the SCPE classification tree), as well as their GMFCS level and complete the names on the list. Refer to appendix A-C.

Inclusion criteria:
- Diagnosed with CP before the age of 2 years old
- GMFCS levels I, II, or III
- Aged between 5.0-14.11 years old at the time of the study
- From any socio-economic, ethnic race, gender, religious or cultural group.
- Receiving Occupational Therapy intervention at school
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Exclusion criteria:
- Severe or profound intellectual disability
- GMFCS levels IV and V
- Uncontrolled Epilepsy
- Diagnosed with a comorbid disorder i.e. Autism, ADHD or any genetic syndrome
- Diagnosed with an acquired brain injury such as near drowning, traumatic brain injury or meningitis after the age of 2 years old.

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The researcher will deliver the Sensory Profile 2 questionnaire, a leaflet explaining how to complete the questionnaire as well as a leaflet explaining sensory modulation in envelopes to the school. These will be given to the learners whose parents/guardians provided consent to participate in the study. A list will be given with all the learners identified. The OT/PT will need to ensure that the envelopes are sent home with the learners in their message books. The parents will need to complete the Sensory Profile 2 questionnaire, which should take them about 15 to

20 minutes to complete. The completed questionnaire will then be sealed in the envelope and returned to the school. The OT/PT will need to collect the envelopes when they are returned. The researcher will make arrangements with the school to collect the sealed envelopes. This will occur outside of teaching time, and thus it will not interfere with the school programme.

What are the risks?
There are no risks involved.

Are there any benefits?
The study will have numerous benefits. Firstly, it will allow Occupational Therapists to better assess and treat these difficulties, as well as make suitable adaptions to the classroom to allow these children cope better which will optimise their learning. Secondly parents/guardians will receive short reports based on their child's results. These reports will be made available to the school therapist provided the parents have given consent to do so. The report will include recommendations to allow parents, as well as the therapists and teachers to accommodate for the child's needs at home and school. This will benefit the quality of therapy and ultimately the children. The results of the study will be published and thus can be applied to other schools in South Africa.

May participants withdraw from the study?
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Kind regards,

Shánna Louwrens
Occupational Therapist
shanna.louwrens@gmail.com
0825639806

CONSENT TO PARTICIPATE IN THIS STUDY

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The content and meaning of this information has been explained to me. I have been given an opportunity to ask questions and am satisfied that they have been answered satisfactorily. I understand that if I do not participate there will be no consequences. I hereby volunteer to take part in this study.

____
Therapist's Name

_________________________ _________________________
Therapist's Signature Date

____
Witnesses' name

_________________________ _________________________
Witnesses' signature Date

____
Researcher's name

_________________________ _________________________
Researcher's signature Date

Appendix G: Participation letter and informed consent form for parents

Dear parent/guardian

My name is Shánna Louwrens and I am an Occupational Therapist at a special needs school in Johannesburg. I am currently completing a research study for a Master of Occupational Therapy degree, at the University of the Pretoria. I am investigating the sensory modulation patterns in children with Cerebral Palsy (CP) and how this affects their behaviour and participation at home and school. I would really appreciate if you would consider participating in this study.

This information leaflet will provide you with information about the study to assist you to decide if you would like to participate in the study. Before you agree to take part in this study you should fully understand what is involved. If you have any questions, which are not fully explained in this leaflet, please do not hesitate to contact me. You should not agree to take part unless you are completely happy about all the procedures involved.

Why am I doing this study?

Sensory modulation refers to how we register and respond to different types of information coming from the different senses in our body i.e. touch, smell, taste, movement, hearing and vision. We know from research that if children have a problem with registering and/or responding to sensations they may behave differently to other children. They might constantly be on the go, want to spin, climb on furniture or fidget with objects. They could also be very sensitive to textures, sounds, or seem fearful of heights or moving. These difficulties may affect their learning, behaviour, attention, social interactions, emotional functioning, as well as their participation in daily activities.

Studies show that children with CP often present with sensory modulation difficulties. This study will assist me in understanding the types of sensory modulation difficulties they might have. The information obtained from this study will allow Occupational Therapists (OTs) to better understand these difficulties, so that they can treat them more effectively in therapy. It will help parents and teachers to understand the child's behaviour at home and school. This information will allow OTs to provide parents and teachers with suggestions on how to adapt the home and school environment so that these children can optimally concentrate, behave and participate in their daily activities.

What are the procedures involved should I choose to participate?

Should you choose to participate in this study, you will be required to:

1. Complete the **informed consent form** (page 3)
2. Complete the **parent questionnaire**. This is a short 2-page questionnaire which will provide more information on your child's medical and background history.
3. Complete the **Sensory Profile 2**. There are 86 questions in the questionnaire and you must tick the most appropriate response. This should take you about 15 to 20 minutes to complete.
4. Complete **report consent form**. After the study, the researcher will send home a short report with your child's results. Please complete this form if you would like the school to receive a copy of the report.

You will find all these forms in the envelope. **Please note that all the questionnaires will be in English.** Although the questions are not complicated, you will need to be able to read and understand English to complete these forms. The researcher will contact you to find out if you have any questions about the study or the questionnaires. You are also allowed to contact the researcher at any time. Once you have completed all the documents, please place them in the envelope and seal the envelope. You must then return the sealed envelope to your child's teacher.

What are the risks?
There are no risks involved.

Are there any benefits?
Yes. The result obtained from this study will assist OTs to better assess and treat sensory modulation difficulties in children with CP. After the study, you will receive a short report of your child's results. The report will include strategies to help your child cope better at home. If you give written consent, a copy of the report will also be sent to the OT treating your child. This information will assist OT's at your school to make the classroom sensory friendly, to accommodate for your child's specific needs. This will help your child to concentrate and learn better at school.

May I withdraw from the study?
You are allowed to withdraw from the study at any time, without having to give a reason. The study is completely voluntary, and there are no consequences if you choose to not take part or if you wish to withdraw from the study.

What about confidentiality?
All information that you send will be sealed in an envelope. Therefore, all sensitive information will remain confidential. Once I receive your documents, the information will be coded to maintain your confidentiality. I will be the only person to have access to the name list and the codes used. Your identity, the identity of your child, and the school will be protected at all times and will not be published or made public at any time. The forms will be kept locked in a cabinet at the University of Pretoria.

Has the study received ethical approval?
This Protocol was submitted to the Faculty of Health Sciences Research Ethics Committee, University of Pretoria, telephone numbers 012 356 3084 / 012 356 3085 and written approval has been granted by that committee **(313/2017)**. The study has been structured in accordance with the Declaration of Helsinki (last update: October 2013), which deals with the recommendations to guide researchers. A copy of the Declaration may be obtained from the researcher should you wish to review it.

If you are willing to take part in the study, please read and sign the attached consent form (page 3). You can keep the information leaflet (page 1 and 2). Please return the consent form, the parent questionnaire, as well as the Sensory Profile 2 questionnaire to your child's class teacher in the envelope and **seal the envelope.**

Please feel free to contact me should you have any questions pertaining to the study or your involvement in the study. You can contact me on 0825639806 or shanna.louwrens@gmail.com.

Kind regards,

Shánna Louwrens
Occupational Therapist

CONSENT TO PARTICIPATE IN THIS STUDY

I have read and I have understood the above information before signing this consent form. I am aware that the questionnaires that I will need to complete are in English, and I am able to complete the forms in English. The content and meaning of this information has been explained to me. I have been given an opportunity to ask questions and am satisfied that they have been answered satisfactorily. I understand that if I do not participate there will be no consequences. I hereby volunteer to take part in this study.

____
Parent/guardian's name

_________________________ _________________________
Parent/guardian's signature Date

____
Witnesses' name

_________________________ _________________________
Witnesses' signature Date

____
Researcher's name

_________________________ _________________________
Researcher's signature Date

Appendix H: Parent background questionnaire

PARENT QUESTIONNAIRE

Thank you for completing this 2-page questionnaire. Please try to answer questions as accurately and as detailed as possible. **Place this form in the envelope when complete.**

A. GENERAL INFORMATION

Child's full name:							
Child's date of birth:							
Child's age:							
Child's gender:							
Child's home language:							
Other language (s) spoken at home:							
Language spoken at school:							
Preferred method of communication:		SMS		Email		Message book	
Child's home address:							
Name of Mother:		Name of Father:					
Occupation:		Occupation:					
Highest grade/level of education?		Highest grade/level of education?					
Has regular contact with the child:	☐ Yes ☐ No	Has regular contact with the child:	☐ Yes ☐ No				
Telephone number:		Telephone number:					
Email address:		Email address:					
Who does the child live with?							
☐ Biological mother	☐ Biological father	☐ Step mother	☐ Step father				
☐ Other family	☐ Guardian	☐ Other					
Does the child have any siblings? If so complete.							
	Name:	Gender:	Age:	Lives with child:			
1.		M/F		Y/N			
2.		M/F		Y/N			
3.		M/F		Y/N			
4.		M/F		Y/N			
5.		M/F		Y/N			
6.		M/F		Y/N			
Describe the home which your child lives in (tick the appropriate box):							
☐ Concrete/ brick house on separate stand	☐ Flat/apartment	☐ Cluster/town house in complex	☐ Informal dwelling				
	☐ Room in house/ backyard	☐ Other Specify:					
What age did your child start school?							
Current school:							
Current grade/section at school:							

B. DEVELOPMENTAL HISTORY

Where was the child born?			
☐ Hospital	☐ Clinic	☐ Home	
Did you experience any of the following symptoms during your pregnancy?			
☐ Threatening miscarriage	☐ Low blood pressure	☐ High blood pressure	☐ Excessive bleeding

PLEASE TURN OVER

Page 1 of 2

Duration of pregnancy			
☐ Full term	☐ Premature Weeks:	☐ Overdue Weeks:	
Type of delivery			
☐ Natural	☐ Planned caesarean section	☐ Emergency caesarean section	☐ Instruments used e.g. forceps/ suction
What was the baby's birth weight?			
☐ <1000g	☐ 1000-1500g	☐ 1500-2500g	☐ >2500g
Were there any complications during birth?			
☐ Baby was blue/white in colour	☐ Baby didn't cry	☐ Baby was put on oxygen How long:	☐ Baby was put in an incubator How long:
How long were you in hospital for?			
Did you baby develop any problems after birth?			
☐ Jaundice (yellow skin/eyes)	☐ Epilepsy/ seizures (fits)	☐ Meningitis/ encephalitis	Hydrocephalus (water on the brain)
☐ Colic (crying a lot, difficult to calm down)	☐ Difficulty breathing (needed oxygen, didn't breathe on own)	☐ Needed surgery/ to be hospitalised	☐ Other Specify:

Describe your child's milestones:					
My child sat	☐ No	☐ Yes	☐ On time	☐ Late	How old?
My child crawled	☐ No	☐ Yes	☐ On time	☐ Late	How old?
My child walked	☐ No	☐ Yes	☐ On time	☐ Late	How old?
My child said their first word	☐ No	☐ Yes	☐ On time	☐ Late	How old?
My child used sentences	☐ No	☐ Yes	☐ On time	☐ Late	How old?

Does your child have any of the following problems currently?			
Visual problems:	☐ Can't see far	☐ Can't see nearby	☐ Wears glasses
Hearing problems:	☐ Can't hear loud noises	☐ Can't hear soft noises	☐ Wears hearing aids
Communication problems:	☐ Unclear speech i.e. it is difficult to understand him/her	☐ My child cannot speak	☐ My child uses a book/computer to communicate
Epilepsy:	☐ Uncontrolled	☐ Controlled	☐ Takes medication for epilepsy
Other medical conditions/ problems:	☐ Asthma	☐ Diabetes	☐ Congenital heart problems
	☐ ADHD	☐ Autism	☐ Genetic condition
	☐ Allergies	☐ Behavioural problems	☐ Other Specify:
Does your child take any medication?	Name: Dosage: Time taken:	Name: Dosage: Time taken:	Name: Dosage: Time taken:
Does your child attend therapy?	Play therapy/ counselling	☐ At school	☐ After school
	Occupational therapy	☐ At school	☐ After school
	Physiotherapy	☐ At school	☐ After school
	Speech therapy	☐ At school	☐ After school

Appendix I: Letter of approval from biostatistician

BIOSTATISTICS UNIT

26 April 2017

LETTER OF STATISTICAL SUPPORT

This letter confirms that **S. Louwrens** from the **Department of Occupational Therapy, Faculty of Health Sciences of the University of** discussed her project: **"Sensory modulation patterns in children with Cerebral Palsy: A comparative-descriptive study using the Sensory Profile 2"** with me. I confirm that I will assist with the statistical analysis of the study data.

Data analysis

The descriptive statistics mean, median, standard deviation and range, with 95% confidence intervals will be used to describe scores from Sensory Profile questionnaire. Categorical variables will be described using frequencies and proportions. ANOVA will be used to test for differences in mean scores between different Cerebral Palsy sub-groups. Post hoc tests will be used to determine which groups differ. A cluster analysis will be conducted to find possible clusters with respect to the scores from the questionnaire. Tests will be evaluated at 5% level of significance. All analysis will be done using STATA 14.

Sample size

The researcher was encouraged to obtain all patients from three different schools in order to have a sample size of 150. This sample size is suggested since the distribution of the numbers in the various CP groups are very low in some groups, compared to the groups with the most patients.

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Biostatistics Unit
MRC Pretoria
012 339 8529
Charl.JansevanRensburg@mrc.ac.za

MEDICAL RESEARCH COUNCIL
Biostatistics Unit
Private Bag X385
Pretoria
0001
Tel: 012 339 8523 / Fax: 012 339 8582

Appendix J: Table of learners

Dear Occupational/Physiotherapist
Your participation in this study is highly appreciated. Please complete the table with all the possible candidates based on the inclusion and exclusion criteria. Please use the SCPE classification tree and GMFCS levels to classify the learners. You only need to classify whether the child is ataxic, dyskinetic, or spastic. If the child is classified as spastic please specify whether they are diplegic, hemiplegic or quadriplegic. Should you have any queries regarding the criteria and classification, please do not hesitate to contact the researcher on 0825639806 or shanna.louwrens@gmail.com.

Date: ______________________________
Name of school: ______________________________
Name of therapist: ______________________________
Profession: ______________________________
Contact details: ______________________________
Email address: ______________________________

Please complete the table with all the possible candidates based on the inclusion and exclusion criteria

No:	Name	Grade/ section:	DOB:	SCPE subtype	GMFCS level:
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Appendix K: Sensory modulation handout for parents

<u>What is sensory modulation?</u>

Our senses give us information on our world around us and help us to survive. The senses receive information from both outside and inside our bodies. We have our 5 main sensory systems i.e.:

- **Auditory:** how we react/respond to different sounds (for example loud, soft) in our environment
- **Visual:** how we react/respond to different types of visual information (for example lights, patterns)
- **Touch:** how we react/respond to touch (for example different textures, temperature) from our environment
- **Movement (vestibular):** how we react/respond to different types of movement and heights
- **Body position (proprioception):** our awareness of where our bodies are in space and how to move them
- **Oral sensory:** how we react/respond to food tastes, smells, textures or sensory feedback in our mouth

Our brain is constantly receiving sensory information from all the sensory systems. You can imagine that it can cause a bit of a "traffic jam" in the brain. Some information is important (like listening to your boss in a meeting) and some information is less important (the fly buzzing in the room). Once the sensation is received the brain needs to decide of the information is relevant (important) or irrelevant (unimportant). If it is important the brain lets it through for more processing, but if it not important the brain blocks it, like a traffic official. After this the brain decides what is going to do with the information and how it is going to react to it and prepares the body to respond to the sensory information. This process is called sensory modulation. Sensory modulation is the ability of the nervous system to regulate, organise, and prioritise incoming sensory information.

Some children (and even some adults) have difficulty with sensory modulation. These difficulties can include not noticing sensory information, constantly responding to unimportant information, or reacting negatively to sensory information. Sensory modulation problems occur when the nervous system is:

- **Under-aroused** i.e. it does not receive enough sensory input or the messages are too weak
- **Over-aroused** i.e. it receives too much sensory input or the messages are too strong.

These difficulties can affect behaviour and emotions, as well as motor responses.

When the child becomes over-aroused (too much sensory information), they are unable to block out sensory input and become sensitive towards it. They may become overly active or silly, have problems focusing their attention, they may display increased anxiety or fear, and they could also become unusually defensive or aggressive or withdrawn. Children who are under-aroused (too little sensory information) may appear unmotivated, slow, or lazy. This is because they are not adequately registering or responding to the sensory input. Some children may also become overactive and fidgety in attempt to increase their level of arousal. They may seek intense movement such as crashing into objects or spinning, they may bite or pinch or become rough to increase their perception of the sensation.

It is normal for there to be fluctuations between over-arousal and under-arousal. For example, you may be able to react in a calm manner to someone hooting in traffic in the morning but become intensely agitated later in the day. When a person is well-modulated they can respond appropriately to different sensations and they can adapt to changes in the environment. Children with modulation difficulties spend most of their time in the over or under aroused states or have extreme fluctuations between the two. They find it difficult to feel calm and focused and this affects their ability to do daily tasks such as washing, dressing, eating and playing.

There are 4 main patterns of sensory modulation:

 **Registration:** These children do not receive enough sensory information from their bodies (under-aroused). They do not actively try and get the information that their body needs. They seem to be uninterested, unaware of their surroundings and they tend to have low energy levels.	**Seeking:** These children do not receive enough sensory information from their bodies (under-aroused) but they actively try and get more information, but it seems like it is never enough, and they are always looking for more. They tend to be busy and, on the go, constantly make noises, fidget, chew on pencils or toys, hang on people or furniture, play rough or break toys easily. 

Avoiding: These children receive too much sensory information from their bodies (over-aroused). They actively try and avoid engaging in activities and they have rigid rituals and routines. They may seem withdrawn or become disruptive to avoid engaging in certain tasks. They may become upset if their routine or ritual is disrupted.		**Sensitivity:** These children receive too much sensory information from their bodies (over-aroused) which causes them to notice stimuli quite easily. They tend to be very distractible and they may become overwhelmed, easily upset or react explosively.

References

Dunn W. The sensations of everyday life: Empirical, theoretical, and pragmatic considerations. Am J Occup Ther. 2001;55(6):608-20.

Dunn W. Sensory profile 2 user's manual. San Antonio: Pearson; 2014.

Appendix L: Instructions on how to complete the SP2

Dear parents/guardians

Thank you very much for expressing an interest and willingness to participate in the research study. This is the Sensory Profile 2 questionnaire. There at 86 questions for you to complete. This should only take 15-20 minutes to complete. **PLEASE ANSWER ALL THE QUESTIONS.**

HOW TO FILL IN THE SENSORY PROFILE

This questionnaire measures your child's sensory modulation abilities i.e. how your child responds to different sensations and how this affects their participation in daily activities. The information obtained from these questionnaires will help me to determine the types of sensory modulation difficulties that children with Cerebral Palsy have. Try to think how often you see your child responding to different types of inputs and mark the appropriate box i.e.

Almost Always - Your child responds in this manner **90% or more** of the time.
Frequently - Your child responds in this manner **75%** of the time.
Half the Time - Your child responds in this manner **50%** of the time.
Occasionally - Your child responds in this manner **25%** of the time.
Almost Never - Your child responds in this manner **10%** or less of the time.

Does not Apply - Please only select this option, if the question does not apply to your child i.e. you have not observed the behaviour before, or you believe that the behaviour does not apply to your child, for example your child is unable to do a particular task.

There are no right or wrong answers. Remember we all process information differently. The answers you give will allow me to get an idea of how your child responds to sensory input. Please be as honest as possible, as this will give the most accurate information. It is preferable that the parent/guardian who spends the most time with the child answers the questions. If you are unsure, please leave the question blank and the researcher will contact you to clarify the question.

Once you are satisfied with your responses, please return the questionnaires to your child's school in the envelope provided and seal it. These forms should be returned by the following date _______________________. Within two-weeks of receiving the forms I will contact you to provide you an opportunity to ask any questions.

I will send you a short report of the findings as soon possible. This may take a few months as there are several participants. Please complete the consent form (page 2) if you give the researcher permission to provide a copy of the report to the Occupational Therapist at your child's school. If you have any queries or need more information, please contact me on shanna.louwrens@gmail.com or 0825639806.

Thank you for your participation.

____
Shánna Louwrens
Occupational Therapist

Appendix M: Informed consent form to provide a copy of the report to the school therapist

CONSENT TO PARTICIPATE IN THIS STUDY

I have read and I have understood the above information before signing this consent form. I am aware that should I sign this consent form, a copy of my child's report will be given to the school Occupational Therapist.

____

Parent/guardian's name

__________________________ __________________________

Parent/guardian's signature Date

____

Witnesses' name

__________________________ __________________________

Witnesses' signature Date

____

Researcher's name

__________________________ __________________________

Researcher's signature Date

Appendix N: Sample of Sensory Profile Report

—CONFIDENTIAL REPORT—

Sensory Profile Summary Report

Name: [redacted]
Date of birth: [redacted]
Age: 6-4 years
Gender: Male
School: [redacted]

[redacted] was assessed using the Sensory Profile 2 as part of a research study. The Sensory Profile 2 is parent/caregiver questionnaire which reflects how a child processes and responds to different types of sensory information. The following is a summary of his results based on the answers provided by the parent/caregiver:

Component	Result	Interpretation
Seeking: *The degree to which a child obtains sensory information.*	Just Like	Children who score "Just Like" obtain sensory information appropriately to participate successfully in daily activities.
Avoiding: *The degree to which a child is bothered by sensory information.*	More Than	Children who score "More Than" or "Much More" may seem more bothered by things that others don't notice. They may be more withdrawn and prefer to play on their own. They often try to avoid unfamiliar situations or sensory inputs that they do not like. They may be bossy or controlling. They can become very upset when things do not go according to plan. They benefit from having a consistent routine. They should be made aware of changes in plans/routines ahead of time. When they become overwhelmed/upset they should be encouraged to go to a quiet or dark room to calm themselves down. Their work area should be tidy and away from bright colours or noise.
Sensitivity: *The degree to which a child detects sensory information.*	Just Like	Children who score "Just Like" are able to detect and respond to sensory input appropriately allowing them to participate successfully.
Registration: *The degree to which a child misses sensory information.*	Much More	Children who score "More Than" or "Much More" tend to miss things that others notice easily. They may take longer to respond when there is a lot happening at the same time. They appear to be more relaxed and they aren't easily bothered by things. They may have less energy or seem uninterested. They may seem unfocused and take longer to complete tasks. They would benefit from being exposed to a variety of intense sensory experiences to allow them to focus and respond to sensory information. Use bright colours/lights; fast movements (running on the spot, spinning, rolling across the room); a louder/excited tone of voice; or spicy/salty/sour food to get their attention and increase their energy levels.
Auditory Processing: *Refers to how the child reacts or responds to auditory (sound) information.*	More Than	Children who score "More Than" or "Much More" may present with more auditory processing difficulties than other children. Children who are auditory avoidant/sensitive may notice sounds quicker than others, become upset by loud/unexpected noises, or cover their ears. They may struggle to block out unimportant sounds (such as the lawnmower) in order to concentrate on important sounds (such as the teacher's voice). Children with poor registration may take long to respond to instructions, or it may seem as though they are ignoring you. Seekers may look for opportunities to make noises while they work. Children who struggle with auditory processing would benefit from working in quiet areas to

		allow them to concentrate better. Before giving instructions ensure that you have their attention. Instructions can be given both verbally (words) and visually (gestures, pictures, or written). Seekers may enjoy listening to music while they do their homework.
Visual Processing: *Refers to how the child reacts or responds to visual information.*	Just Like	Children who score "Just Like" process and respond to visual information just like the majority of others.
Touch (tactile) Processing: *Refers to how the child reacts or responds to tactile information.*	More Than	Children who score "More Than" or "Much More" may present with more tactile processing difficulties than others. Tactile seekers may touch others/objects or fidget with their stationery, which may negatively affect their concentration. Tactile avoidant/sensitive children may become extremely upset during grooming activities. Their clothes, shoes and socks may bother them. Children with poor registration may not notice pain, temperature or that their hands are dirty. It is important to expose children to a variety of tactile experiences; such as playing with dough, painting with their fingers, hiding toys in beans/rice, or writing spelling words in sand/flour/shaving foam. For sensitive children use firm-touch pressure (such as hugs, weighted blankets/clothes, or vibrating toothbrushes). It may be helpful to cut out clothing tags or buy tighter fitting clothes. Rather use firm touch than light touch, and avoid touching them unexpectedly, or when they cannot see you.
Movement (vestibular) Processing: *Refers to how the child reacts or responds to movement and heights.*	Much More	Children who score "More Than" or "Much More" may present with more vestibular processing difficulties than others. Children with poor registration do not adequately register vestibular information, which may affect their balance and posture. Sensory seekers may be more active, look to climb very high, spin/rock, or enjoy crashing into things. They may struggle to sit still at the table. Sensitive children may be fearful of moving or heights, get sick when driving, avoid lifts or dislike playing on jungle gyms. Children should be exposed to different types of movement; such as spinning, rolling, climbing, jumping, swinging etc. Children who seek movement, may need more intense movement to meet their needs. They would benefit from having short movement breaks during the day to assist them to concentrate; for e.g. jumping/running on the spot, spinning 5 times, walking on their hands/backwards/sideways or sitting on a ball or air-cushion.
Body Position (proprioception) Processing: *Refers to how the child processes information from their muscles and joints.*	Much More	Children who score "More Than" or "Much More" may present with more proprioceptive processing difficulties than others. Children with poor registration do not get sufficient information from their bodies, and they may seem weak or tired. Proprioceptive seekers may push harder when writing, break their toys, grind their teeth, or hang onto people/furniture. Include heavy work activities during the day; such as carrying shopping bags or laundry, playing with dough, or crawling under pillows/a mattress. A heavy toy or blanket can be placed over their legs; bean bags can be placed in their jacket pockets; or they can sit on a ball or air-cushion while doing school or homework.
Oral Sensory Processing: *Refers to how the child reacts or responds to smell, taste and textures in their mouth.*	Just Like	Children who score "Just Like" process and respond to oral sensory information just like the majority of others.

Conduct: *Refers to behavioural challenges that the child may experience due to their sensory processing difficulties.*	More Than	Children who score "More Than" or "Much More" have more conduct difficulties associated with sensory processing than others. They may be more active or accident prone than other children. They may be stubborn or have frequent temper tantrums. They may work very slowly, or do things in a harder way than is needed. Help them to plan and organise their work, give them one task at a time or a time limit. Star charts or rewards may motivate them to work carefully. Allow them to have short movement breaks to acquire more sensory feedback to concentrate.
Social emotional: *Refers to social/emotional challenges that the child may experience due to their sensory processing difficulties.*	More Than	Children who score "More Than" or "Much More" have more social emotional difficulties associated with sensory processing than others. They may be overly serious and lack a sense of humour. They may become very upset when they are criticised; when they are unsuccessful at a task; or when things do not go according to plan. They may struggle to make friends. Help them to recognise their feelings and how to react appropriately, for e.g. "You are feeling angry because your homework is difficult. Take a deep breath, and let's try together.", or "Zoe wants to be your friend, why don't you say hello and ask her to come and play."
Attentional: *Refers to attentional difficulties that the child may experience due to their sensory processing difficulties*	More Than	Children who score "More Than" or "Much More" have more attentional difficulties associated with sensory processing than others. They may be easily distracted or stare at people/objects. They may not be able to block out unimportant sensory information, especially in busy or multisensory environments. They may struggle to complete tasks. Pack away unnecessary things on their desk, remove distracting posters and have a quiet area for them to do their homework. Encourage them to finish a task before starting the next task i.e. do one thing at a time. Allow them to have short movement breaks to acquire more sensory feedback to concentrate.

The following are areas of difficulty/concern:

- Avoiding
- Registration
- Auditory Processing
- Touch (tactile) Processing
- Movement (vestibular) Processing
- Body Position (proprioception) Processing
- Conduct
- Social emotional
- Attentional

The following are areas of strength:

- Seeking
- Sensitivity
- Visual Processing
- Oral Sensory Processing

Conclusion:

The results obtained from the Sensory Profile 2 indicate that [redacted] has some sensory processing difficulties, which may be interfering with his performance in daily activities and/or school.

Recommendations:

1. [redacted] would benefit from Occupational Therapy to further evaluate and address his possible sensory processing difficulties.
2. It is important for [redacted] to be exposed to sensory activities to allow him to adequately process and react to these inputs.

Thank you for your participation in the research study. Should you have any queries regarding your child's results, please feel free to contact me on 0825639806 or shanna.louwrens@gmail.com.

Shánna Louwrens
Occupational Therapist
October 2017

Appendix O: Ethical clearance letter

The Research Ethics Committee, Faculty Health Sciences, University of Pretoria complies with ICH-GCP guidelines and has US Federal wide Assurance.
- FWA 00002567, Approved dd 22 May 2002 and Expires 03/20/2022.
- IRB 0000 2235 IORG0001762 Approved dd 22/04/2014 and Expires 03/14/2020.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences Research Ethics Committee

14/08/2017

Approval Certificate
New Application

Ethics Reference No: 313/2017

Title: Sensory modulation patterns in children with Cerebral Palsy: A comparative-descriptive study

Dear Miss Shanna Louwrens

The **New Application** as supported by documents specified in your cover letter dated 31/07/2017 for your research received on the 10/08/2017, was approved by the Faculty of Health Sciences Research Ethics Committee on its quorate meeting of 14/08/2017.

Please note the following about your ethics approval:
- Ethics Approval is valid for 1 year
- Please remember to use your protocol number (**313/2017**) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, or monitor the conduct of your research.

Ethics approval is subject to the following:
- The ethics approval is conditional on the receipt of **6 monthly written Progress Reports**, and
- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

We wish you the best with your research.

Yours sincerely

Dr R Sommers; MBChB; MMed (Int); MPharMed,PhD
Deputy Chairperson of the Faculty of Health Sciences Research Ethics Committee, University of Pretoria

The Faculty of Health Sciences Research Ethics Committee complies with the SA National Act 61 of 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 and 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes, Second Edition 2015 (Department of Health).

012 356 3084 fhsethics@up.ac.za http://www.up.ac.za/healthethics
Private Bag X323, Arcadia, 0007 - Tswelopele Building, Level 4, Room 60, Gezina, Pretoria

Appendix P: Approval letter from Post Graduate Committee

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences

6 June 2017

Faculty Ethics Committee
Faculty of Health Sciences
University of Pretoria

To whom it may concern,

Student S Louwrens (MOccTher) 27057314
Sensory modulation patterns in children with Cerebral Palsy: A comparative-descriptive study

This letter serves to confirm that the abovementioned protocol was resubmitted and approved following the School Postgraduate meeting of 24 May 2017 and referred to the School Academic Advisory Committee and Faculty Ethics Committee for final discussion.

Sincerely yours,

pp. Professor J Mothabeng
Chairperson: School Core Research and Proposal Review Committees

Room 4-55, HW Snyman North
University of Pretoria, Private Bag X20
Hatfield 0028, South Africa
Tel +27 (0)12 3541900
Natalie.marais-werner@up.ac.za
www.up.ac.za

Fakulteit Gesondheidswetenskappe
Lefapha la Disaense tša Maphelo

Appendix Q: Approval letter from the Department of Education

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	20 June 2017
Validity of Research Approval:	06 February 2017 – 29 September 2017 2017/151
Name of Researcher:	Louwrens S.
Address of Researcher:	PostNet Suite 108
	Private Bag X1037
	Germiston, 1400
Telephone Number:	082 563 9806
Email address:	shanna.louwrens@gmail.com
Research Topic:	Sensory modulation patterns in children with Cerebral Palsy: A comparative- descriptive study using the Sensory Profile 2
Number and type of schools:	Five LSEN Schools
District/s/HO	Gauteng East, Gauteng North and Gauteng West

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

21/06/2017

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

1

Making education a societal priority

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.education.gpg.gov.za

1. The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.
2. The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.
3. A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.
4. A letter / document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.
5. The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.
6. Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.
7. Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.
8. Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.
9. It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.
10. The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.
11. The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.
12. On completion of the study the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.
13. The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.
14. Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

Ms Faith Tshabalala
CES: Education Research and Knowledge Management

DATE: 21/06/2017

Office of the Director: Education Research and Knowledge Management
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