EFFECT OF THE WILBARGER DEEP TACTILE AND PROPRIOCEPTIVE TECHNIQUE ON BEHAVIOUR AND SALIVARY CORTISOL IN CHILDREN WITH SENSORY PROCESSING DIFFICULTIES

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DECLARATION

I, Genna Irving declare that this research report is my own work. It is being submitted for the degree of Master of Science in Occupational Therapy applied to Perceptual Disorders in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

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Genna Irving (Signature of Candidate)

30th day of April 2015

DEDICATION

I am honoured to dedicate this research report to my parents, Timothy and Maureen Irving, and my brother, Brett Irving. Your commitment to our family and unwavering faith have been my source of strength and encouragement to allow me to achieve all that I have wanted. To my husband, Sebastien Delsemme, you have profoundly impacted my life and your dedication and belief in me have provided me with motivation, safety, security and deep joy. I would also like to honour my faithful God and Father, my Rock and Comforter, who pours His grace into my life daily and carries me through.

ABSTRACT

This study investigated the short-term changes in behavioural regulation and salivary cortisol before and after administration of a single application of the Wilbarger Deep Tactile and Proprioceptive Technique (DTPT) in children with Sensory Modulation Dysfunction (SMD).

In a pre- and post-test research design, the negative behaviours as well as the salivary cortisol levels of 21 participants was assessed before and after administration of the Wilbarger DTPT.

Statistically, significant changes were found for negative behaviours related to participants' concentration, attention, and readiness for a task; their behaviour in the group, and their perseverance and task completion. Children with sensory overresponsivity benefited the most from the intervention. The association between salivary cortisol levels and therefore, sympathetic nervous system arousal and the Wilbarger DTPT, was confirmed. Higher baseline cortisol levels were found for participants with sensory overresponsivity, decreasing significantly in the post-test, while the opposite was found for participants with sensory underresponsivity.

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OPERATIONAL DEFINITIONS

1. Adaptive response – a successful response to an environmental challenge (Bundy et al., 2002).

2. Negative behaviour – in the presence of sensory modulation dysfunction, input is not only inappropriately modulated, it also fails to generate adaptive behavioural responses, interfering with all occupations and roles, from which we infer that neural modulation of sensory information is faulty.

   i. Negative behaviours linked to sensory overresponsiveness (sensory defensiveness) include: a need to control the sensory environment to avoid aversive sensory inputs, disorganised responses, increased distractibility to irrelevant incoming sensory input, irregular emotional tone, lability, extreme need for personal space, and disruption in personal care or intimacy in relationships.

   ii. Negative behaviours linked to sensory underresponsiveness include: decreased awareness of important environmental stimuli to derive meaning for action, failure to notice opportunities for engagement, lethargy, apathy, and unmotivation, a withdrawn response pattern, and decreased inner drive for initiating exploration and socialisation.

   iii. Negative behaviours linked to sensory seeking include: disorganisation, hyperactivity, impulsiveness, restlessness, a disregard for physical boundaries, attention-seeking, continuous movement or busyness, a constant need to be taking risks, spinning, touching or watching objects.

These and other behaviours may disrupt classroom performance and behaviour in a group, making learning difficult, and also negatively affecting self-esteem and relationships (Bundy et al., 2002, James et al., 2011, Miller et al., 2007b).

3. Optimal Arousal – the “typical” mid-range where performance, learning and attention are at their peak, of which each individual’s is unique, as every person needs an optimal level of stimulation to achieve an optimal state of arousal (Wilbarger and Wilbarger, 2012a).

4. Responsiveness – a behavioural manifestation of sensory modulation in which a person with disturbances in sensory modulation may display over- or under-responsivity to sensory input (Miller et al., 2007c).

5. Self-Regulation – the ability to produce adaptive, organised behaviour during structured tasks, including: sustained concentration, task completion, the ability to divide attention between focused activities and monitor one's own behaviour in context before it becomes a problem (Bundy et al., 2002). Children with sensory modulation demonstrating severe over- or under-responsiveness to sensation have an inability to restore homeostasis or self-regulation due to disturbances in autonomic nervous system functioning, influencing their ability to participate in activities (McIntosh et al., 1999a).

6. Sensory Overresponsiveness / Sensory Defensiveness (terms used interchangeably in the literature) – "a constellation of behaviours related to aversive or defensive reactions to non-noxious stimuli across one or more sensory systems" caused by an imbalance within the evaluative system in the brain that assigns "negative" or "harmful" valence to non-noxious stimuli leading to changes in arousal, affective tone and stress Page 5:(Wilbarger and Wilbarger, 2012a, Bundy et al., 2002, Lane et al., 2010).

7. Sensory Diet – the total daily controlled sensorimotor input needed by an individual to achieve and maintain optimal levels of arousal for performance and adaptive interaction with the environment, which is incorporated into a treatment plan with carefully timed and selected sensory-based activities used in the context of daily life. These activities reflect the principles of sensory integration theory (Bundy et al., 2002).

8. Sensory Integration – the neurological processes (including modulation, discrimination, perception and practic functions) used by an individual to organise sensation received from his or her own body and the environment around him or her for producing a complex set of adaptive responses. The term also refers to a frame of reference used in the treatment of children with deficits in these neural functions and interpreting sensation (Bundy et al., 2002, Ayres, 1972).

9. Sensory Modulation – the ability to produce adaptive, graded responses to sensation over a broad range of intensity and duration such that the intensity,

degree, and nature of the response matches the environmental demand (Lane, 2002b, Schaaf and Smith Roley, 2006).

10. Sensory Modulation Dysfunction – a pattern of dysfunction of sensory integration in which an individual over- or under-responds to sensory input from the body or environment (Bundy et al., 2002).
11. Sensory Processing – functions related to the interpretation of sensation occurring in the central nervous system including reception, modulation, integration, and organisation of sensory stimuli, as well as the behavioural response to sensory input (Bundy et al., 2002).
12. Somatosensory Input – certain types of sensory experiences that are effective in reducing defensive responses to sensation including deep pressure touch and proprioception (i.e., muscle resistance, joint traction and compression). These types of sensation influence modulation of and adaptation to environmental sensory input producing a physiological response (Wilbarger and Wilbarger, 2012a, Bundy et al., 2002).
13. Sympathetic Arousal – reflects the functioning of the autonomic nervous system which regulates the child's state of readiness to respond in a fight, flight or fright manner (Schaaf et al., 2010b).
14. Tactile Defensiveness – a subtype of sensory overresponsiveness marked by "fight or flight" reactions to touch that most others would consider non-noxious.
15. Wilbarger Deep Tactile and Proprioceptive Technique – a professionally guided treatment technique involving the use of a specific densely bristled therapressure brush which, when administered correctly, provides very deep pressure (without tickle or scratch) applied to the hands, arms, back, legs and feet, followed by compression or approximation of joints in the trunk, arms and legs (Bundy et al., 2002).

LIST OF ABBREVIATIONS

ANS	Autonomic Nervous System
ADL	Activities of Daily Living
CNS	Central Nervous System
DTPT	Deep Tactile and Proprioceptive Technique
ELISA	Enzyme-linked Immunosorbent Assay
SPD	Sensory Processing Disorder
SMD	Sensory Modulation Disorder
SSP	Short Sensory Profile
SP	Sensory Profile
ADHD	Attention Deficit Hyperactivity Disorder
ASD	Autistic Spectrum Disorder
SOR	Sensory Overresponsiveness
SUR	Sensory Underresponsiveness
SS	Sensory Seeking
RAS	Reticular Activating System
SAM	Sympatho-Adrenal-Meduallry
HPA	Hypothalamic-Pituitary-Adrenal
PDD-NOS	Pervasive Developmental Delay Not Otherwise Specified
RCT	Randomised Controlled Trail
SI	Sensory Integration
WITS	University of the Witwatersrand
DSM-V	Diagnostic and Statistical Manual
SD	Standard Deviations
SD	Sensory Defensiveness
WHO	World Health Organisation

OT-SI Occupational Therapy – Sensory Integration

ICD-10 International Statistical Classification of Diseases and Related Health Problems

TENS Transcutaneous Electrical Nerve Stimulation

CHAPTER 1: INTRODUCTION

Children who present with Sensory Modulation Disorders (SMD) exhibit the inability to regulate the degree, intensity and nature of responses to sensory stimuli in a graded, adaptive manner. Responses that are inconsistent with the demands of a situation are observed in these children, as well as inflexibility in adapting to the sensory challenges of everyday life (Miller et al., 2007b, James et al., 2011).

The heterogeneity and complexities of a diagnosis of SMD, classified as a type of sensory processing disorder (SPD), poses challenges for discussions related to theory, diagnosis and intervention. Numerous symptoms have been identified as being part of SMD, however, the most clearly understood and defined are the symptoms of sensory defensiveness (Kimball et al., 2007). In their continuing education courses, Wilbarger and Wilbarger highlight that an overreaction of normal protective senses is elicited in the presence of sensory overresponsiveness, but that each individual has a unique response style (Wilbarger and Wilbarger, 2012a).

Despite there being different response patterns, research has begun to show that recent advances in physiological methods hold promise for accurately identifying sensory overresponsivity. Neurophysiological functioning may be used as a biomarker for differentiating the diagnosis of sensory overresponsiveness as physiological dysregulation has been found to underlie defensive responses to sensation. Researchers suggest that this is marked by patterns of poor habituation to stimuli, an escalation of arousal states, sympathetic overactivity (increased stress response), and decreased parasympathetic nervous system functioning, resulting in poor return to normal arousal levels (Miller et al., 2007b, Schaaf et al., 2010a, Schaaf et al., 2003, Miller, 2003b, McIntosh et al., 1999).

These underlying deficits in physiological functioning result in increased responsiveness to everyday sensory stimuli. This leads to unpredictable behaviour and a poor range of adaptive responses, resulting in the child having difficulty participating successfully in various life contexts. Due to disruption of the normal evaluative system in the brain, children with sensory overresponsiveness perceive their environments to be dangerous, fearful and anxiety-provoking. Thus, these children remain in a constant state of threat (Wilbarger and Wilbarger, 2012a).

It has been theorised over time that anxiety is “the result of faulty information processing, as well as hypersensitivity to information and stimuli in the environment” Page 2:(Lane et al., 2010). Ayres suggests that children who display atypical responses to sensory stimuli due to deficits in modulating incoming sensation, experience behavioural consequences including anxiety, distractibility, impulsivity, high activity levels, and other stress related behaviours (Lane et al., 2010, Ayres, 1972). These behaviours significantly impact on the child’s self-regulation, self-esteem, school performance, social skills, and activities of daily living (Schaaf et al., 2003, Cohn et al., 2000, McIntosh et al., 1999, Parham and Mailloux, 2001).

The Wilbarger protocol is widely used by practitioners in the intervention of children and adults with SMD. Based on the principles of Ayres’s work in the field of sensory integration (Ayres, 1964), in 1965 Patricia Wilbarger initially developed a protocol primarily to treat tactile sensory overresponsiveness in children identified as being overresponsive to touch (Wilbarger and Wilbarger, 2012a), It was postulated that passively imposed touch stimulation desensitised the tactile system in a child who would otherwise display avoidance of and defensive responses to new stimuli.

Later, as the theory was expanded and differentiated, sensory overresponsiveness became recognised as one type of sensory modulation dysfunction that could involve not only the tactile system, but all sensory systems (Wilbarger, 1995). Therefore, passively imposed touch - fundamentally recognised and recommended by Ayres (Ayres, 1972) for the treatment of the tactile system - is now considered also to influence other systems in a child with sensory overresponsiveness (Kimball et al., 2007).

Wilbarger and Wilbarger expanded further on Patricia Wilbarger’s initial protocol and developed a comprehensive treatment strategy for individuals with sensory overresponsiveness (Wilbarger and Wilbarger, 1991). This extended Wilbarger protocol involves three elements which include an awareness of the sensorimotor problems, a specific, individualised sensory diet incorporating different calming, organising and alerting sensory inputs provided in a controlled manner, and the Wilbarger Therapressure protocol (Wilbarger and Wilbarger, 2012a). The latter is commonly referred to as “brushing”, inaccurately so, by the general population and is described in the literature as the “Deep Tactile and Proprioceptive Technique”

(DTPT), which will be the term used in this research report to refer to this component of the protocol (Wilbarger and Wilbarger, 1991, Kimball et al., 2007).

The Wilbarger protocol requires the occupational therapist to use an intense and individualised treatment approach based on an initial assessment of the client using advanced clinical reasoning to identify key defensive symptoms. This first step is important for raising awareness and providing education aimed at changing perceptions of both the parent and the child from seeing symptoms as emotional and learnt behavioural patterns. They need to understand the symptoms as reactions of the Central Nervous System (CNS) in response to environmental stimuli misidentified as noxious or even harmful.

A sensory diet is an activity plan designed to decrease sensory overresponsiveness with the use of modulating activities and precise timing to help the client stay calm yet organised and alert. Timing, intensity, duration, and the sensory qualities of the activities prescribed for the sensory diet are specified and occur within the client's normal environments (Wilbarger and Wilbarger, 2012a). The use of a sensory diet in the treatment of SMD is based on the premise that each individual requires a certain amount and specific types of sensory input every day to be optimally alert, skilful and adaptable.

While the three treatment components are important, the DTPT is the most carefully administered component of the intervention programme for sensory overresponsiveness. It is a guided treatment technique meaning that direct application or monitoring by an occupational therapist is required. This somatosensory intervention is, therefore, only used in selected cases.

The protocol requires precision in the application and frequency of use and must be performed repeatedly throughout the day, according to the prescribed schedule of every two and a half hours. It should only be administered by occupational therapists following a specific training programme, as aspects such as the correct pressure and technique are essential to delivering the whole process without noxious input (e.g., scratch or tickle), in order to produce modulation. Occupational therapists require caregivers to use the technique, however, it must only be used when the person administering the technique is carefully trained and can commit to the recommended daily schedule (Wilbarger and Wilbarger, 2012a). Caregivers are

trained to provide very deep touch pressure to the skin, using a specifically manufactured non-scratching therapressure brush, followed by joint proprioception given through systematic compressions to major joints.

No empirical evidence is, however, currently available explaining the immediate effect of the DTPT on reducing the negative behavioural manifestations from which children with sensory overresponsiveness suffer.

1.1 STATEMENT OF THE PROBLEM

Despite the widespread use of the DTPT, occupational therapists working with it have had limited theoretical understanding of the neurological processes involved that help modulate a client's CNS responses and, therefore, behavioural responses to environmental stimuli.

If an emphasis is placed on determining the underlying neurological mechanisms responsible for changing behavioural symptoms, this could allow for more effective treatment approaches to be employed. Anecdotal evidence has been used to describe the effectiveness of the Wilbarger protocol in causing behavioural changes in the treatment of sensory overresponsiveness. However, controlled research designs have been difficult to achieve given the variability in the conditions under which the protocol is prescribed as well as the differences in individual diagnoses of the clients receiving the protocol.

Behavioural manifestations and the impact of sensory overresponsiveness have been reported in the literature to an extent (Wilbarger and Wilbarger, 2012a, Wilbarger and Wilbarger, 1991, Dunn, 1997, Dunn, 2007, Miller et al., 2007b, Miller et al., 2012). Sensory overresponsiveness has been shown to decrease social, cognitive, and sensorimotor functioning in children (Dunn, 1997). Descriptions provided by researchers in the field over the past 50 years focus more on global functional deficits and sensory processing impairments related to this type of SMD. However, the immediate, short-term behavioural changes that can be observed following a single application of the Wilbarger DTPT, have not previously been investigated.

Deep pressure touch and proprioception are both sources of calming and organising inputs to the CNS facilitating the maintenance of an optimal arousal state. These

sensory inputs, when provided through the DTPT, were reported to be effective in regaining a state of optimal arousal by a recent pilot study. This study, performed in 2000, was the first to use more objective, scientific methods to examine the effect of the Wilbarger protocol-based procedure. Their methods were able to test the change in the sympathetic nervous system by measuring salivary cortisol levels. According to the apparent association reported in the findings, salivary cortisol levels moved in the direction of modulation expected, suggesting that children may gain a more modulated state of arousal from a single application of the Wilbarger DTPT (Kimball et al., 2007).

The question that arises from the findings of the above-mentioned research is whether salivary cortisol changes are consistent with immediate behavioural changes. If so, this evidence would support longstanding parental reports and clinical observations made by occupational therapists treating children with SMD. The authors of the pilot study stated that this finding was only preliminary yet promising enough to warrant further research. The study findings are limited to physiological functioning but do not provide evidence for the modulating effect on behavioural responsiveness that can be expected immediately after application of the technique (Kimball et al., 2007).

1.2 THE PURPOSE OF THIS STUDY

The purpose of the present study was to explore the behavioural responsiveness in children with disturbances in sensory modulation and the relationship to physiological functioning, specifically sympathetic nervous system responses, following administration of the Wilbarger DTPT. Behavioural responsiveness was firstly measured by the short-term change in the number of observations of non-desirable behaviours linked to SMD. Secondly, the presentation of self-regulatory behaviours was measured. Video recordings of children engaged in an Activity protocol (Miller et al., 2007e) before and after receiving the Wilbarger DTPT, as a pre-and post-test measure of behavioural modulation, were used. Salivary cortisol levels were tested to determine the effectiveness of the Wilbarger DTPT in altering physiological responses immediately following the intervention procedure. The research question tested by the current study was as follows: What is the short-term effect of the Wilbarger DTPT on behavioural modulation, self-regulation and

sympathetic nervous system responses, and what is the relationship between these outcomes in children with sensory modulation difficulties?

1.3 THE AIM OF THE STUDY

The aim of the study was to measure immediate changes in behavioural modulation by observing behavioural symptoms and self-regulation present before and after administrating the Wilbarger DTPT in children who present with SMD, according to the Sensory Profile (Dunn, 1999). The study further investigated whether there are short-term changes in sympathetic arousal, as measured by salivary cortisol levels, and whether these are associated with behavioural changes observed following a single application of the Wilbarger DTPT.

1.4 OBJECTIVES OF THE STUDY

The objectives of the study were to determine:

- the change in negative and self-regulatory behaviours present, measuring behavioural modulation of participants while engaged in an Activity protocol prior to and following a single administration of the Wilbarger DTPT
- the change in salivary cortisol levels tested before and after children received a single administration of the Wilbarger DTPT intervention
- the association between the change in behavioural modulation and change in salivary cortisol levels in children with SMD.

1.5 NULL HYPOTHESIS

The Wilbarger DTPT does not have an immediate influence on the negative behaviours associated with sensory modulation dysfunction, or change self-regulation or salivary cortisol levels from a once-off application.

1.6 JUSTIFICATION OF THE STUDY

There is an increasing demand for occupational therapists to place greater importance on intervention that is founded on sound evidence available, which is as far as possible, scientific and research-based. The far-reaching negative consequences of sensory overresponsiveness are seen to be present in many diagnostic categories and affect many children and adults. Occupational therapists

use the Wilbarger protocol widely to treat the nervous system of individuals with sensory overresponsiveness and to improve their behaviours and ability to participate more fully in their daily occupations. Occupational therapists who use the Wilbarger technique need empirical evidence substantiating its effect and success in treating clients with sensory overresponsiveness.

While much anecdotal evidence is available, up until the recent pilot study by Kimball et al., there has been no way of evaluating the DTPT using objective means (Kimball et al., 2007). Previous research has confirmed that salivary cortisol, the hormone associated with increased sympathetic arousal, is a reliable measure of the physiological stress response (Bear et al., 1996, de Haan et al., 1998, Lumley et al., 1995). Now that cortisol can be effectively measured in saliva, sympathetic nervous system changes that occur following use of the DTPT can be evaluated directly.

The results of the current study provide evidence related to the way in which the Wilbarger DTPT modifies salivary cortisol levels and, therefore, arousal or stress levels theoretically, following a single application of this procedure to a larger sample of participants than used previously. The changes that occur in cortisol levels are further linked to the immediate changes observed in behaviour, which have not been examined to this point and therefore fill a gap in the literature. The evidence of the study contributes to the body of knowledge validating this preferred technique of choice in the treatment of sensory overresponsiveness. It explains the effect on the responsiveness of clients' CNS to the environment and corresponding behavioural changes. Therefore, a better understanding of the relationship between functional behaviour in children with SMD and sympathetic functioning was gained from examining the foundational data.

CHAPTER 2: LITERATURE REVIEW

This chapter will review sensory integration and sensory processing as well as the different types of sensory modulation disorders. The relationship between SMD and the nervous system as well as the effects on behaviour will also be considered. Evidence available describing the effectiveness of the Wilbarger protocol used in the occupational therapy intervention for SMD will be examined.

2.1 SENSORY INTEGRATION

Sensory integration is a developmental process through which the brain acquires the ability to organise sensory information. For the infant, once challenges in the environment are successfully met, the brain learns to organise sensation. This leads to the infant developing increasingly more complex adaptive responses with each environmental challenge successfully achieved (Parham, 1998, Paul et al., 2003). As the infant grows, its ability to produce a developmentally appropriate range of motoric, attentional and emotional responses to sensory stimuli becomes fundamental to its ability to adapt to challenges encountered in everyday life (Ayres, 1964, Kinnealey et al., 1995, Ahn et al., 2004, James et al., 2011).

Ayres, the pioneer of sensory integration therapy, developed methods of treatment that facilitated normal development of sensory integration and modulation in children, as a basis for enhancing successful participation in daily occupations (Parham and Mailloux, 2001). She achieved this through use of sensory-based activity linking it to neuro-behavioural theory to help the client develop adaptive responses (Kimball et al., 2007). Ayres defined an adaptive response as

> "an appropriate action in which the individual responds successfully to some environmental demand" Page 22:(Ayres, 1972).

The sensory integrative process, therefore, facilitates successful responses allowing the child to meet the current environmental demand resulting in adaptive responses.

2.1.1 Sensory Processing Disorder (SPD)

Individuals from various clinical populations, who are unable to achieve and maintain developmentally appropriate responses, displaying signs of inefficient processing of sensory input, have been identified by occupational therapists, as having a sensory disorder since the 1960s. Ayres originally identified this in her first scholarly articles as sensory integrative dysfunction (Ayres, 1963, Ayres, 1965). However, the validity of sensory integrative dysfunction as a diagnosis, now referred to as sensory processing disorder, is continually questioned in emerging literature.

A new nosology postulating specific diagnostic criteria has recently been published, differentiating three patterns of SPD: sensory modulation disorder, sensory discrimination disorder, and sensory-based motor disorder. The taxonomy further delineates subtypes within each pattern based on extensive empirical analysis. This evolutionary model provides researchers and clinicians the opportunity to achieve homogeneity in sample selection for future research studies, based on specific attributes of SPD subtypes (Miller et al., 2007b).

Although SPD is not currently recognised as a diagnosis by the International Statistical Classification of Diseases and Related Health Problems (ICD-10) or by the Diagnostic and Statistical Manual (DSM-V), recognition of the diagnosis has escalated (Cheng and Boggett-Carsjens, 2005). The diagnosis of SPD has recently been acknowledged outside the profession of occupational therapy in three diagnostic classification references including the Diagnostic Manual for Infancy and Early Childhood (ICDL) (Interdisciplinary Council on Developmental and Learning Disorders, 2005), the Diagnostic Classification of Mental Health and Developmental Disorders of Infancy and Early Childhood, Revised (DC:0-3R) (Zero to Three, 2005), and the Psychodynamic Diagnostic Manual (PDM Task Force, 2006).

Despite the recognition gained for SPD as a valid diagnosis, there has been much dispute related to the effectiveness of sensory integration therapy as the preferred method of treatment used in the intervention of SPD. A recent surge of scholarly articles has highlighted the need for empirical outcomes research investigating a sensory integration approach (Taylor, 2000, Tickle-Degnen, 2000, Miller et al., 2007d). The current controversy related to this approach is fuelled by the

discrepancy in findings presented by efficacy studies, as results vary widely and are inconclusive (Miller et al., 2007d).

In light of this, there is a greater demand on the profession to produce high-quality, rigorous evidence substantiating intervention using a sensory integration approach. There is increasing emphasis in the medical field on ensuring effective outcomes whilst achieving cost containment. However, given the absence of high-quality evidence supporting this approach (Miller, 2003a), the cost-to-benefit ratio in the treatment of SPDs cannot be validated to date.

The variance in available results substantiating the use of the sensory integration approach is predominantly related to the heterogeneity of the population with which it is used, affecting the validity of findings (Miller et al., 2007b, Schaaf and Nightlinger, 2007).

The recently proposed nosology for diagnosis, however, allows greater clinical diagnostic precision, resulting in the selection of more homogenous samples in empirical research. This will increase power in effectiveness studies (less sample variance) and improve intervention planning for specific clinical cases. Validity of the available research is further reduced by outcome measures used in the literature, which are not “occupation” based, posing a threat to conducting relevant research (Schaaf and Nightlinger, 2007).

The goal of occupational therapists applying a sensory integrative approach is to:

> “improve the child’s ability to process and integrate sensory information as a basis for enhanced independence and participation in daily life activities, play (including social participation) and school tasks” Page 2:(Schaaf and Miller, 2005).

However, identifying standardised means to measure the array of meaningful, functional outcomes makes implementing research, to determine the effectiveness for sensory integration therapy, complex. This has resulted in evidence to date essentially being based on subjective, anecdotal data usually reported by families, individuals, and therapists directly involved in the treatment process (Mailloux et al., 2007).

There is much debate as to whether the Wilbarger protocol can be considered as part of a sensory integration approach. Therapists who believe it to be inconsistent

with Ayres's original therapeutic concepts, criticise the therapist-guided, passive technique used in the application of touch. According to Ayres's theory of sensory integration, the child needs to be self-directed, with therapist guidance, for sensory integration to occur (Ayres, 1964, Ayres, 1972).

Ayres' SI intervention is based on specific priniciples critical to the effectiveness of this therapeutic process. These have been outlined in a fidelity measure recently published to ensure therapists' adherence to the approach(Parham et al., 2011). Therapy is contextualised in sensory-rich play that taps into the inner drive of the child for competence. The therapist skillfully creates an enticing environment and provides achievable challenges to promote the child's ability to process and integrate sensory input and produce adaptive responses (May-Benson and Koomar, 2010). Creating a play context is a core construct where the therapist remains responsive to the child's needs so that there is collaboration on activity choices while providing sensory opportunities.

Thus, use of the Wilbarger protocol is controversial, as it is sensory stimulation applied to the child and consequently goes against the major premise that the child should self-initiate and collaborate on the therapeutic activity. The goal of the Wilbarger protocol is to help individuals live more comfortably in their environments (Roley and Wilbarger, 1994). However, individuals with defensiveness tend to avoid anything new and, therefore, would not seek out activities that could change their sensory systems to achieve this goal. Ayres recognised this problem and recommended that, at times, passive intervention be used in order to overcome it, explaining that,

"Occasionally…it seems best for a therapist to impose tactile stimuli at first to help the child get over the initial defensive stage" Page 116:(Ayres, 1972).

This applies particularly in SMD where there is overresponsivity to sensations due to over-activation of the anterolateral protective system in the brain. This system signals danger in response to most light, unpredictable touch sensation (even unthreatening) and prevents the child from engaging in everyday occupations. Whereas, deep pressure touch and proprioception travel up the dorsal-column-medical-lemniscus system. The information carried along this pathway to the brain has a powerful modulating effect on the nervous system. Therefore, the Wilbarger

protocol is used as an adjunct to SI therapy to provide sensory stimulation that is both calming and organising to the somatosensory system for long-term neurophysiological change.

2.1.2 Sensory Modulation Disorder (SMD)

The ability to modulate responses to sensory experiences of daily life provides a foundation for purposeful and meaningful participation in a full range of occupations. Sensory modulation disorder, described by Lane, Miller and Hanft (2000), is characterised by impairments in detecting, interpreting, modulating, and responding to sensation (Miller et al., 2007d). Prevalence studies estimate that sensory modulation disorder affects 5% to 16% of the general population of school age children (Ahn et al., 2004, Ben-Sasson et al., 2009).

Children with inefficient sensory modulation often display difficulty regulating their responses to sensory stimuli and struggle to meet successfully the challenges encountered in everyday life. If the central nervous system is unable to regulate the neural message sent to the brain regarding the sensory input received, responses are inconsistent with the demands of the situation. Children are often unable to adapt to different environments (Miller et al., 2007b).

Key to identifying SMD is the severity and degree to which individuals are unable to regulate everyday sensory stimulation, as it is typically sensory stimuli to which most people easily adapt. Despite immense individual differences, SMD occurs only when the difficulties in regulating sensory input impair daily roles and routines (Miller et al., 2007b, James et al., 2011). Participation in everyday activities such as playing, mealtime, social interaction, dressing and bath time are impeded by the unusual patterns of sensation-seeking or avoiding, that these individuals display (Schaaf et al., 2010b). These behaviours result from extreme hyper- or hypo-sensitivity to typical levels of sensation (Dunn, 1997). Families are often impacted by the extreme emotional states that these individuals frequently experience, such as intense fear, anger, depression, hostility, and anxiety (Schaaf and Smith Roley, 2006). According to parent's reports, the significant difficulties experienced by their children include poor self-regulation and social participation, as well as poorly perceived self-confidence (Cohn et al., 2000).

As with SPD, the clinical presentation of SMD varies considerably due to the heterogeneity in symptomatology. Involvement of one or more of the seven sensory systems - visual, auditory, tactile, vestibular, proprioceptive, olfactory, and/or gustatory - may be present. The categories of SMD stated in the diagnostic manuals by the 0-3 organisation (Zero to Three, 2005) and the Interdisciplinary Council of Developmental and Learning Disorders (Interdisciplinary Council on Developmental and Learning Disorders, 2005) were synthesised into three subtypes from the new taxonomy recently published. These include sensory underresponsivity, sensory seeking/craving, and sensory overresponsivity. However, a combination of symptomatology may also occur (Miller et al., 2007b).

Within each subtype, diverse atypical behaviours resulting from sensory modulation dysfunction can be described, and these range from mild to severe. Therefore, heterogeneity in symptomatology of SMD is seen clinically, depending on which sensory systems are involved and the degree, manner, and severity of symptoms (Miller et al., 2007b, James et al., 2011, Kinnealey et al., 1995, Lane et al., 2000).

As early as 1964, an association between tactile overresponsiveness and distractible, hyperactive behaviour was identified (Miller et al., 2007b) by Ayres, who considered a difficulty in modulating tactile input as the only pattern of SMD, which she labelled tactile defensiveness (Ayres, 1972). Later, Dunn proposed a quadrant classification scheme after conducting a factor analysis of behaviours from the Sensory Profile, a parent-report measure which she developed (Dunn and Brown, 1997, Dunn, 1999). The four quadrants included low registration, sensation seeking, sensory sensitivity and sensory avoiding. Dunn also reported neurological thresholds to sensory input, as being either high or low, and described different regulatory strategies in combination with these thresholds. Individuals who act in accordance with their thresholds, display passive regulatory strategies, while active regulatory strategies may also be employed to counteract a threshold.

However, the issue of what terminology most accurately describes the variations in the presentation of sensory modulation dysfunction has been vigorously debated. Wilbarger and Wilbarger (Wilbarger and Wilbarger, 2012a) consider sensory processing on a continuum with defensive and avoidant behaviours on one end and joyful exploration of sensation on the other. They recommend using a carefully

constructed sensory history interview and observation for diagnosing SMD, primarily because they consider each individual to have his or her own response pattern (Wilbarger and Wilbarger, 2012a, Wilbarger and Wilbarger, 1991). Therefore, they recognise that an individual with sensory overresponsiveness may exhibit patterns of sensory seeking, avoidance, anxiety, fear, and even aggression. These symptoms may be misidentified as being emotionally based and can fluctuate widely.

Miller and her colleagues used a more complex ecological model of sensory modulation to define structure within their data, in order to describe more homogenous patterns of SMD. They used a sample of children with fragile X syndrome, attention-deficit/hyperactivity disorder (ADHD), autism spectrum disorder (ASD), and SMD (Miller et al., 2001). The authors accounted for the internal and external factors influencing the individual's ability to maintain a state of homeostasis.

These models and conceptualisations contain face validity and are clinically useful for understanding the variability in the presentation of SMD when considering proposed patterns of dysfunction. They explain the same important phenomena, however, the clinical heterogeneity of SMD had not been researched using scientific methodologies to determine if this classification into subtypes is valid, until a recent study by James, Miller, Schaaf, Nielson and Schoen in 2011 (James et al., 2011). The study used cluster analysis to group behavioural characteristics of sensation, emotion, and attention frequently noted in children with SMD, as clinically reported in the literature (Mailloux and Burke, 1997, Miller et al., 2001, Davies and Gavin, 2007, Reynolds and Lane, 2008, Schoen et al., 2009).

This research was based on the hypothesis that SMD can be clustered into meaningful subtypes including sensory seeking/craving, sensory underresponsivity, and sensory overresponsivity. The results from this study provide empirical data confirming the accuracy of this clinical classification model for the first two subtypes (James et al., 2011). Sensory seeking/craving and sensory underresponsivity were identified as distinct subtypes of SMD, which are characterised by poor socialisation, hyperactivity, impulsivity, maladaptive, externalising (e.g., aggressive) behaviour and movement sensitivity, weakness/low energy, and emotional withdrawal behaviour. The two most distinguishing variables of these two subtypes were

reported as hyperactivity (sensory seeking/craving) and movement sensitivity (sensory underresponsivity), respectively (James et al., 2011).

2.1.3 Sensory Processing Patterns Associated with Subtypes of SMD

The study described above provided partial support for the nosology delineating the three subtypes of SMD as sensory seeking/craving, sensory underresponsivity, and sensory overresponsivity (Miller et al., 2007b, James et al., 2011). Sensory overresponsive behaviours, including overresponsivity to taste, smell, tactile, visual, and auditory input, were found in the clusters of both those with sensory underresponsiveness and the sensory seekers/cravers. This implies that sensory overresponsivity and underresponsiveness are not on the same continuum, as has previously been hypothesised (Lane, 2002b). In fact, sensory underresponsivity and movement sensitivity may occur concurrently in the same group of children (James et al., 2011). Although these findings, validating sensory overresponsiveness as a separate pattern of SMD, are recent and lack support, research investigating this proposed subtype is available and is currently emerging. Furthermore, parent-report tools primarily focus on measuring attributes of sensory overresponsiveness, as well as sensory seeking/craving (James et al., 2011).

2.1.3.1 Sensory Overresponsiveness (SOR)

Overresponsivity to sensation may involve multiple sensory systems (i.e., sensory defensiveness), or occur only in one sensory system (i.e., tactile defensiveness) (Miller et al., 2007b). For the purpose of this research report, the term “sensory overresponsive” will be used to describe this subtype of SMD. The term “sensory defensive” is also used in the literature to describe the same subtype of SMD. Prevalence rates reported by a population-based study conducted in America showed that sensory overresponsivity was present in 2.8% to 6.5% of school-aged children across tactile, movement, taste-smell, and visual-auditory domains (Ahn et al., 2004).

Sensory overresponsivness, or defensiveness, is seen as responses to sensation which are atypical, quicker in onset, more intense, and longer lasting than is expected of children with more typical sensory responsivity, given the nature of the stimulus (Miller et al., 2007b). A child with typical threshold sensitivity is able to adapt

within constantly changing sensory environments but for the child with overresponsivity, the same stimulation is perceived as harmful, threatening, or noxious. The automatic, unconscious reactions produced in response to ordinary levels of sensation in the environment are physiological. These cause sympathetic nervous system activation, resulting in exaggerated fight, flight or freeze behaviours (Brett-Green et al., 2010).

Earlier theory hypothesised that these behaviours result when the protective pathway dominates (Fisher and Dunn, 1983). This concept has been redefined and the “protective” component of sensory processing is now more accurately termed the evaluative system or the low-route pathway (LeDoux, 2003). This pathway is responsible for more than a general alerting function in the nervous system. Its primary functions involve

> “generalized alerting, preparation for action (approach or avoidance) and processing of low-level affective or highly learned information” Page 16:(Wilbarger and Wilbarger, 2012a).

Disruption in this evaluative system in the brain, seen in the presence of sensory overresponsiveness, results in over-evaluation of incoming stimuli from the environment, triggering a fear-based response. When the perceived level of threat is overlaid on the existing state of heightened arousal in the child’s nervous system, he or she responds in a heightened fashion with the purpose of safety and survival (Kimball et al., 2007). These behaviours interfere with a child’s learning and ability to engage in daily occupations.

Preliminary findings suggest that sensory overresponsivity is marked by a distinctive pattern of poor habituation to sensory stimuli. Increasingly, researchers are investigating biological markers as a means to discriminate this disorder (Brett-Green et al., 2010). Ayres’s original hypothesis stated that children with sensory overresponsiveness were unable to inhibit irrelevant sensory information (Ayres, 1972). A study based on this premise measured multisensory integration of simultaneous auditory and somatosensory stimulation using high-resolution event-related potentials recorded on thirty-two scalp electrodes. This advanced technology allowed accurate measurement of the timing of sensory processing to determine exactly when and where it was occurring in the brain. The findings suggested that

multisensory integration can be reliably measured in children with sensory overresponsivness using this technique (Brett-Green et al., 2010).

Event-related potentials as well as electrodermal and neuroendocrine (salivary cortisol) measures have been used as biological markers for this subtype of SMD. Neurophysiology studies have shown that the atypical neural mechanisms for integrating sensory stimuli in children with sensory overresponsivity also produce sensory and behavioural symptoms that can be profound. Frequently reported symptoms include sensitivity to auditory and tactile input, these being the most common domains studied in the literature and seen in children clinically identified with sensory overresponsivity (Ben-Sasson et al., 2009, Goldsmith et al., 2006).

The behavioural effects caused by overresponsiveness in the auditory and somatosensory systems have been well documented in behavioural studies. Findings have shown that overresponsivity in these systems is associated with psychological and emotional disorders (Kinnealey and Fuiek, 1999, Kinnealey et al., 1995, Pfeiffer et al., 2005, Neal et al., 2002). The child's quality of life is impacted by these psychological and emotional deficits, which interfere with his or her engagement in social interactions. He or she experiences difficulty participating in play and other occupations of childhood as typical children would. This prevents his or her successful engagement in home and school routines or within community environments (Lane, 2002a, Cohn et al., 2000, Schoen et al., 2008, Kimball et al., 2007).

Wilbarger and Wilbarger acknowledge that symptoms of overresponsiveness fluctuate widely (Wilbarger and Wilbarger, 2012a). In order to understand the subtle differences of sensory overresponsiveness and to identify accurately a child's response pattern, the primary sensory overresponsive behaviours, secondary related difficulties, and coping strategies used by the child must be assessed. It is important to expand on these behaviours, difficulties and coping strategies to provide a more detailed explanation of what can be considered as primary, secondary or coping behaviours. Primary behaviours, as mentioned, may include either the active, negative, aversive, defensive reactions to sensory experiences, or the more passive, avoidant, or withdrawal responses (Wilbarger and Wilbarger, 2012a, Miller et al., 2007b).

Identified as fight, flight, or freeze reactions manifested in the presence of overresponsiveness, these responses create secondary associated problems. The responses are not specific defensive behaviours, but rather related to having overresponsivity to stimuli that most individuals would not find noxious. Anxiety, stress, and distractibility are common secondary problems resulting from being in a state of constant vigilance needed to defend against the possibility of exposure to stimuli experienced as threatening. Clinically significant levels of anxiety have been reported in a sample of children with ADHD and co-morbid sensory overresponsivity when assessing total anxiety, compared to children with ADHD but no sensory overresponsivity (Reynolds and Lane, 2008). Overresponsivity has therefore been linked to clinically impaired arousal, attention, and impulsivity in the child, noted to be particularly evident when they are placed in new and unfamiliar environments, or during transitions.

This overresponsive subtype of SMD is, thus, often coupled with sleep difficulties, postural and physiological disruptions (gastroenterology problems, postural tension), as well as social and emotional disturbances including emotional fragility, irritability, poor socialisation, and aggressive behaviour. Children displaying these symptoms employ a range of coping strategies to modulate and reduce the negative impact to disturbing sensory input. These strategies present as either avoidance of events, sensations, environments, or social interactions, or as controlling behaviours seen in rigid routines (Miller et al., 2007b, Wilbarger and Wilbarger, 2012a).

2.1.3.2 Sensory Seeking/Craving (SS)

Although children with sensory overresponsiveness engage in sensory seeking behaviour in an attempt to self-regulate, there is a specific atypical response pattern characteristic of sensory seeking/craving, a distinct subtype of SMD. Importantly, the degree of sensory seeking behaviour is in the extreme, excessive of that expected of a typically developing child seeking sensation to explore, learn and master new challenges. Research and clinical observations have shown that these children crave an unusual amount of sensory input, for which their desire for sensation appears to be insatiable. This need constantly to obtain additional sensory

stimulation, leads to an increased arousal state causing behaviour to become even more disorganised (Miller et al., 2007b).

Thus, the hyperactive, impulsive, restless behaviour displayed by children in this subtype, and the active “bashing and crashing” resulting from a need to engage in actions, provide more intense sensation. However, these behaviours are often deemed socially inappropriate (disregard for physical boundaries), unacceptable (constantly moving, busy or active), and unsafe, or may even be misinterpreted as being attention-seeking. Children who meet criteria for sensory seeking are excessive in their quest for sensory input to the point that it interferes with learning, due to a disruption in attention. For the child who constantly needs to be taking risks, moving, spinning, touching or watching objects, and/or seeking loud sounds or unusual olfactory and oral experiences, it impacts on his or her ability to function in daily life. These children have been found to have poor school performance and social interaction, and experience difficulties in completing activities of daily living (James et al., 2011, Miller et al., 2007b).

2.1.3.3 Sensory Underresponsiveness (SUR)

Children with underresponsiveness to sensation appear not to notice, or to disregard important stimuli in the environment, as they do not detect incoming sensory information. This lack of initial awareness results in the child being perceived as lethargic, apathetic, and seemingly unmotivated. The withdrawn response pattern is not due to a decreased inner drive for initiating exploration and socialisation but, rather, it is caused by a failure to notice important stimuli and derive meaning for action from these stimuli. Typically, a failure to respond to extreme pain or fluctuations in temperature is well documented in the literature (Miller et al., 2007b, James et al., 2011).

It is frequently reported that sensory underresponsivity is not readily detected in the infant or toddler. Since the demand for interaction increases when the child reaches preschool, these children lack the necessary arousal levels required for active participation. Therefore, children within this subtype are noticed when their availability and interaction across contexts are limited, because they need more salient, intense input to become involved in activities (Miller et al., 2007b).

Research has recently begun to investigate the underlying theoretical constructs in SMD by explaining the involvement of the central nervous system, and specifically, autonomic nervous system responses.

2.1.4 Association between Sensory Modulation Disorder, Autonomic Nervous System (ANS) Functioning and Behavioural Outcomes

The level of alertness maintained by the brain, referred to as arousal, is primarily a brainstem function of the Reticular Activating System (RAS). This is due to extensive interconnectivity between the RAS and all sensory systems. In the presence of neurological thresholds, the central nervous system is able to modulate physiological responses to stimuli through two mechanisms working in parallel - habituation (high thresholds) or sensitisation (low thresholds). Responsiveness is decreased or increased respectively, depending on whether a stimulus is recognised by the limbic system as being familiar, or potentially threatening (Dunn, 2007, Kimball et al., 2007, Bundy et al., 2002).

The ability of the central nervous system to balance responses between sensitisation and habituation to stimuli permits the young child to gain a more modulated state of arousal. When a child achieves this “calm-alert” state, through the functioning of the RAS in conjunction with the limbic system, the child experiences more optimal sensory registration, orientation and arousal. This aspect of modulation is fundamental in allowing the child to regulate, organise and prioritise incoming sensory input. Hence, habituation and sensitisation influence adaptive responses (Bundy et al., 2002, Demopoulos, 2009).

In the case of sensory overresponsiveness, sudden exaggerated responses are often elicited to seemingly trivial events, due to the summative effect of sensory input. Consequently, sensory input accumulates over the events of the day, placing the child in a constant state of heightened anxiety (Wilbarger and Wilbarger, 2012a, Miller et al., 2007b). Defensive behaviours are compounded due to a lack of habituation to stimuli, in which case a state of “sensory overload” or “sensory shutdown” (protective inhibition) is reached. If an individual with overresponsivity perceives a new stimulus – which is otherwise non-threatening - as potentially dangerous, the strong survival responses elicited may seem out of line with the intensity of the new stimulus. However, Kimball et al. explains that,

> “the response does not seem out of line when the arousal state of the whole nervous system is considered” Page 407:(Kimball et al., 2007).

When a child is unable to achieve a “calm-alert” state due to poor habituation to stimuli, deficits in neural processing (with low level thresholds), sympathetic dominance, and suboptimal parasympathetic functioning to regulate recovery from sensation, severe over-arousal may result. This may cause the child to go into a state of sensory shutdown, a protective mechanism against severe sensory overload. In such a state he or she is unable to respond to internal or external stimuli. This condition that Wilbarger and Wilbarger describe is the most serious behavioural outcome noted in children with sensory overresponsiveness (Wilbarger and Wilbarger, 2012a).

The concept of self-regulation is largely a function of the autonomic nervous system by means of the reciprocating actions of the sympathetic and parasympathetic pathways, allowing adaptation to incoming sensory inputs from the environment (Schaaf et al., 2003). Dominance in sympathetic pathways places a child in a constant state of high arousal, displaying fight-or-flight reactions. Parasympathetic nervous system activity works to restore the body to a regulated state of arousal following exposure to a stressor or challenge, maintaining homeostasis (Schaaf et al., 2003).

Research investigating the nature of sensory processing problems has primarily addressed behavioural patterns of dysfunction using factor analysis and multivariate and psychometric methods to explain these behavioural categories (Miller et al., 2007b, Bundy et al., 2002, Dunn, 1999). While this research provides useful evidence to clinicians for guiding practice, the underlying physiological mechanisms of SMD are not explained by behavioural data. This could have implications for the development of future intervention strategies and, in addition, the lack of support for current therapeutic techniques targeting these underlying systems is of concern (Schaaf et al., 2010a). Research examining whether atypical sympathetic and parasympathetic nervous system activity is a significant physiological factor in SMD, is thus beginning to emerge.

2.1.4.1 Sympathetic and Parasympathetic Nervous System Activity Linked to Sensory Overresponsive Responses

Studies have shown that children with SMD characteristically displaying over responsiveness to stimulation have increased sympathetic dominance, thus they remain in a state of constant over-arousal. This leads to the experience of continuous stress and vulnerability with sympathetic nervous system activation, due to poor return to normal arousal levels, linked physiologically to increased tonic arousal (Wilbarger and Wilbarger, 2012a, Venables and Christie, 1980). The difficulty in recovering from a stressful situation, also related to decreased parasympathetic activity, has consequences for the child's ability to adaptively cope with a wide range of altering stimuli (Bundy et al., 2002, Bar-Shalita et al., 2008). This results in the child remaining in a hyper-vigilant state within his or her environment, making it difficult for him or her to adapt to the demands of a situation (Lane et al., 2010).

Thus, overresponsiveness, has been linked to deficits in prefrontal cortex/ hippocampal synaptic gating and "bottom-up" processing differences. Nigg's current emerging theory explains this as stimulus-driven reactive control behaviours, which involve striatal or limbic activation (Nigg, 2006). This description of reactive control is seen in the child acting out in response to stimuli that are perceived as potentially dangerous. Levy (2004) also linked the prefrontal cortex/ hippocampal gating deficit to serotonergic and noradrenergic responses in the amygdala, when studying anxiety in children with ADHD (Levy, 2004). Based on his findings, it has been theorised that this gating deficit in children with sensory overresponsivity allows access to amygdala fear reactions. This was concluded by earlier findings in a study by Royeen and Lane in 1992 and supported by more recent research in the field, confirming that a relationship between sensory overresponsivity, ADHD and anxiety exists (Lane et al., 2010). However, specific loci in the CNS, responsible for sensory overresponsive reactions, have not yet been identified.

Investigators have begun to examine these fear-based reactions by using different physiological markers to measure sympathetic nervous system activity involved in the stress response. Miller and her colleagues used a laboratory paradigm measuring electrodermal reactivity - a reflection of sympatho-adrenal-meduallry (SAM) activity - and salivary cortisol levels - a reflection of changes in the

hypothalamic-pituitary-adrenal (HPA) axis - to assess these responses (Reynolds et al., 2010, Hanrahan et al., 2006). The study was conducted among a heterogeneous sample of children with sensory overresponsivity, including mixed clinical diagnoses. An increase in response magnitude lasting for prolonged periods during a sensory challenge was found, when compared to typical controls (McIntosh et al., 1999, American Psychiatric Association, 2000). Thus, with typical levels of sensory stimulation, excessive autonomic nervous system activation and arousal can be assumed.

The authors of the study concluded that the children with SMD, specifically SOR, have sympathetic overactivity compared to typically developing children. Specifically, the results showed that reactions to stimuli perceived as threatening, mimic a physiological stress response, since changes are reflected in the HPA axis and are seen as increased SAM activity. Thus, preliminary research supports a link between cortisol, electrodermal reactivity, anxiety, and sensory overresponsivity when examining responses to sensory challenges (Lane et al., 2010).

Research has shown the system that secretes cortisol, responsible for the stress response, is the HPA system and that sympathetic arousal of the CNS is directly related to cortisol levels (de Haan et al., 1998). Cortisol is, therefore, used to evaluate the HPA system as well as sympathetic arousal because it increases

> “reliably and linearly in response to a wide range of physical and physiological stressors” Page 470:(Lumley et al., 1995).

When the plasma-borne protein binding capacity for cortisol released into the general circulation is exceeded, the unbound cortisol is excreted into saliva (Schulz et al., 1997). When measuring cortisol levels, the best method is to analyse the levels expressed in saliva, which occurs within as few as five minutes after exposure to a stimulus. This results in cortisol concentrations in saliva being directly proportional to blood concentrations (Schmidt, 1997). Cortisol levels in urine, on the other hand, cannot be linked to a specific stimulus due to the delay between a stimulus and the production of urine. In addition, urine samples cannot take into account the variance in cortisol levels that follow a circadian rhythm, when collected over 24 hours. Using blood sampling creates temporary increases in cortisol levels due to anxiety related to the method of collection (Lumley et al., 1995). Therefore,

given the disadvantages described, salivary assessment of cortisol is the preferred method of evaluating the stress response.

An understanding of the underlying physiological mechanisms is incomplete without research explaining the role that parasympathetic nervous system activity plays, as several studies have shown it to be an important regulator of reactivity in children. Reported findings, related to the mechanisms of the sympathetic and parasympathetic branches of the autonomic nervous system, suggest that children with SMD have disturbances in the reciprocal functioning of these systems. Biomarkers of sympathetic overactivity with decreased activity in the parasympathetic nervous system predict stress, risk of vulnerability to sensation, and a poor ability to cope with everyday sensation.

A recent pilot study and follow-on study considered the role of the parasympathetic nervous system in the process of self-regulation and adaptation to internal and external environmental demands. The results indicated that children with SMD had significantly lower vagal tone when compared to typical children. This was measured using a vagal tone index assessing heart rate variability, a measure of baseline parasympathetic nervous system activity. In addition, baseline parasympathetic nervous system activity was lower in children with the most severe sensory behaviours, suggesting a relationship between these two variables. The authors, therefore, concluded that lowered parasympathetic nervous system activity may be a reliable biomarker for SMD (Schaaf et al., 2003, Schaaf et al., 2010a). Decreased parasympathetic nervous system activity was further associated with reduced homeostasis and a narrow range of behavioural adaptation. This finding was noted by Miller to be consistent with additional studies that reported

> “decreased parasympathetic functioning (to be) associated with stress vulnerability, developmental and cognitive delays, and emotional and behavioural over-reactivity” Page 8:(Miller, 2003a).

The physiological mechanisms involved in SMD have not, however, been understood previously, and although researchers have begun to close the gap between understanding the underlying mechanisms and providing support for targeted therapeutic interventions, the evidence is still sparse. There remains a need to address this gap in order to produce data supporting interventions addressing the

underlying physiological mechanisms of SMD. This will allow related behavioural deficits to be targeted and help children to participate more successfully within their environments.

2.1.4.2 Occupational Performance and Behavioural Outcomes Related to Sensory Overresponsiveness

In a systematic review published in 2010, the available evidence related to challenges in occupational performance for children and adolescents with difficulty processing and integrating sensory information was interpreted. The justifications provided for the relationship between sensory processing challenges and associated performance deficits was found to be elusive for all the studies. This was due to a number of limiting methodological flaws in the research reviewed, including the use of primarily cross-sectional designs, the lack of control groups, and specific outcome measures related to occupational performance. Thus the use of small, convenient, heterogeneous samples was a key limiting factor, making it difficult to generalise the results (Koenig and Rudney, 2010).

Despite the lack of rigorous scientific methods used to explain the far-reaching consequences of sensory overresponsivity, some evidence was provided to support a link between sensory overresponsivity and decreased occupational performance (Koenig and Rudney, 2010). Findings reported at level V evidence in case studies indicated that patterns of sensory overresponsivity interfere with self-care performance. Restricted taste preferences and overresponsiveness to tactile stimulation were most commonly reported as primarily disrupting family routines and activities of daily living (Schaaf et al., 2003, Reynolds and Lane, 2008) as children with sensory overresponsiveness found it difficult to tolerate everyday sensory input such as the way the seams of their socks or clothing felt on their bodies, or the sound of a toilet flushing (Schaaf et al., 2010a).

This, in turn, meant that children with SMD became distressed when exposed to these sensations and were found to have significantly poorer adaptive behaviour in their daily living and communication subdomains as well as poor overall “adaptive behaviour composite” scores, as measured on the Vineland assessment. The child may, therefore, be at risk of behavioural difficulties, social isolation, and learning disabilities (Schaaf et al., 2010a). The latter is of particular concern given the

difficulty these children experience in paying attention. Since the child has to use enormous control and effort to succeed in adapting to ordinary stimulation, it is problematic for him or her to maintain his or her attention on task. Currently, one of the main treatment approaches used by occupational therapists to target these problem behaviours and occupational performance deficits is the Wilbarger protocol (Kimball et al., 2007).

2.2 THE WILBARGER PROTOCOL

This paper has discussed how the diagnosis of SMD varies considerably in its clinical presentation, resulting in heterogeneity in symptomatology, including sensory overresponsivity, sensory underresponsivity, sensory seeking/craving, or a combination of the symptoms from these three subtypes (James et al., 2011). An in-depth understanding of how the disorder presents is essential when considering the use of the Wilbarger protocol in practice, and when assessing the available evidence investigating its effectiveness. Research published on the efficacy of this approach, mainly uses heterogeneous samples including children from all three subtypes of SMD (Weeks et al., 2012).

Furthermore, clinicians report using the protocol for treating the wide-ranging symptomology that presents with this diagnosis. However, the Wilbarger protocol was primarily designed to treat defensiveness in the tactile system in children aged 2-12 years (Davis et al., 2011, Weeks et al., 2012, Wilbarger and Wilbarger, 2012a, Bundy et al., 2002). The protocol has been reported to be extensively used by American paediatric occupational therapists (Sudore, 2001) (Weeks et al., 2012), with 15 000 health practitioners worldwide having received specialised training in the protocol (Kimball et al., 2007). The Wilbarger protocol fundamentally consists of three components: firstly, education through which awareness is raised regarding the symptoms related to sensory overresponsiveness; secondly, a specific, individualised sensory diet; and finally, an individualised professionally guided treatment programme, currently referred to as the Wilbarger Therapressure programme (Wilbarger and Wilbarger, 1991, Wilbarger and Wilbarger, 2012a). The last component is referred to in the literature as the Wilbarger “Deep Tactile and Proprioceptive Technique” (DTPT). The terms used to refer to this technique include, “brushing”, the “sensory summation technique” and the “Therapressure”

protocol (Avanti Educational Programs, 2013). “Therapressure” is the most appropriate term, given that application involves continuous deep pressure so as to avoid noxious stimuli (scratching or tickling), by limiting light touch input (Wilbarger and Wilbarger, 2012a, Weeks et al., 2012). Though “brushing” is often used by the general population to describe this technique, the term is misleading and does not accurately convey the intent of this intervention (Bundy et al., 2002).

A detailed understanding of the Wilbarger protocol, as it is intended to be prescribed, is important when considering available evidence, since the studies published use variations in the implementation of this approach.

2.2.1 The Wilbarger Protocol as an Evidence-Based Approach

The use of homogenous samples are needed to validate targeted intervention approaches with scientific evidence (Miller et al., 2007b). The validity of the research published on the efficacy of the Wilbarger protocol has, however, been affected by the use of small heterogeneous samples (Weeks et al., 2012).

The research investigating the effectiveness of the Wilbarger protocol in the treatment of sensory overresponsivity has essentially been limited to non-randomised, single group, pre-post test study designs using small sample sizes, with some descriptive case studies published. However, despite this being low level evidence, which is not conclusive in supporting the efficacy of the Wilbarger protocol, the reviews and studies published provide emerging evidence supporting the effectiveness of the intervention. The majority of the studies show a decrease in sensory overresponsive behaviours and an increase in positive behaviours (Foss et al., 2003, May-Benson and Koomar, 2010, Weeks et al., 2012).

Peer-reviewed journals, abstracts and conference slides, as well as gray literature and other reports on the apparent efficacy of the intervention will be discussed, regardless of the limitations in study designs. This is essentially due to the paucity of literature available, related to the ongoing clinical debate as to whether the Wilbarger protocol is an effective intervention. According to the Australian National Health and Medical Research Council’s hierarchy of evidence, the highest level of evidence available on this topic is currently level IV intervention evidence (National Health and Medical Research Council, 2009). This is the lowest level of evidence in

the hierarchy, with four studies meeting the necessary criteria, all of which are case series with pre- and post-test outcomes (Weeks et al., 2012).

One of the four studies was a pilot study conducted recently using objective physiological measures, assessing salivary cortisol levels of participants to indicate the effects of the Wilbarger DTPT on the physiological system. Although the study only used a single subject design, attempts were made to control co-intervention. Standardised, valid and reliable outcome measures were employed, which had not been reported previously in the literature (Weeks et al., 2012). Interestingly, participants' salivary cortisol levels moved in the direction of modulation expected, with high and low baseline (pre-test) measures decreasing and increasing correspondingly, following application of the DTPT (Kimball et al., 2007).

The association reported in the findings that children may gain a more modulated state of arousal from this professionally guided treatment technique, should be investigated further to determine whether autonomic nervous system changes are consistent with behavioural changes, in supporting longstanding clinical observations made by occupational therapists using this intervention.

An important limitation of the pilot study was that the measures of cortisol were not taken in the natural environment following normal activity. In addition, participants included in the sample (n=4) all had a primary diagnosis of sensory overresponsivity but were both over-and under-responsive to sensation. Finally, similar to other studies, the protocol duration was not tested as prescribed, because measures were taken following only a single application of the Wilbarger DTPT (Kimball et al., 2007, Weeks et al., 2012).

A separate study published subsequent to this pilot study, also using standardised, valid and reliable outcome measures, investigated whether adherence to a timed schedule determines the effectiveness of the DTPT. According to the authors, the effectiveness of the Wilbarger Therapressure programme is not determined by adhering to a timed schedule, and administration of the DTPT should be dependent on the needs of the child, rather than on prescribed time intervals (Benson et al., 2011).

The case study design (n=2) included children who were expected to demonstrate successful responses to the technique, and who each had different diagnoses. The

participant with autistic spectrum disorder (ASD) who received the DTPT, was compared with a control participant with pervasive developmental delay not otherwise specified (PDD-NOS), who received a non-specific child-guided technique; however, the examiner was not blinded to group allocation (Weeks et al., 2012). Of interest, the child with ASD demonstrated the greatest improvement in the areas of “behaviour regulation” and “following social conventions” on the School Function Assessment, with a 4% increase from pre- to post-test outcomes in both categories (Benson et al., 2011).

An additional study of level IV evidence, which also included a child with ASD, using a single subject (n=1), withdrawal (ABA) study design to examine the effects of the DTPT on stereotyped behaviours, reported negative findings about the Wilbarger protocol. Davis, Durand and Chan concluded that the DTPT did not decrease the level of stereotypy (hand flapping, body rocking, finger flicking) in a boy with autism (Davis et al., 2011).

Baseline measures did not improve following a five-week intervention period, although measures of stereotypy were repeated six months after the intervention phase was completed, at which time improvements were noted. These were not marked improvements and thus, the DTPT was not deemed effective in improving stereotypy in the brushing or non-brushing phase (Davis et al., 2011). The study did not collect data regarding treatment fidelity and conducted functional analyses of only a single participant. However, observations were made in the child’s natural environment, a weakness of the pilot study previously mentioned, and inter-observer agreement was conducted to reduce bias from numerous therapist observations during functional analysis (Davis et al., 2011, Weeks et al., 2012).

Finally, the three intervention studies with level IV evidence already discussed, were published in America, with the forth being an Australian study conducted by Stagnitti, Raison, and Ryan (Stagnitti et al., 1999). Although this research is not as recent, it is a comprehensive case report (n=1) presenting observations of a child with sensory overresponsivity syndrome, specifically describing the diagnosis and treatment of (moderate) tactile defensiveness. Initially, after administering the DTPT for a period of two weeks, the participant demonstrated improvements in a number of areas according to reports from his mother.

These included improvements in social and group participation, decreased incidence of temper tantrums at school, with improvements in hand-eye and foot-eye coordination. Additionally, the participant displayed risk-taking behaviours for the first time and accepted being touched by others. Further improvements were reported at six and nine months following initiation of the protocol, with age-appropriate scores achieved for all areas of the Miller Assessment of Preschoolers after six months. Distinct changes were also noted on the sensory checklist, from baseline to follow-up (Stagnitti et al., 1999). However, the limitations of this study compromise the findings, as there was a lack of standardised assessments for determining sensory outcome measures, no formal observation tools, and co-intervention occurred (Weeks et al., 2012).

All four of the studies addressed did not use the Wilbarger protocol in its entirety, as it is intended to be prescribed and implemented. Kimball, Lynch, Stewart, Williams, Thomas and Atwood adapted the Wilbarger protocol by using the DTPT in isolation, administering a single application to each of the four participants. This was carried out during weekly occupational therapy sessions, over four weeks (Kimball et al., 2007). It was not clearly reported in the study who administered the intervention or what other interventions were offered during this scheduled time (Weeks et al., 2012). The frequency of DTPT was prescribed in the study by Benson, Beeman, Smitsky and Provident as three times during school hours (9am, 11am, 1pm) with a continuous schedule maintained at home by parents, for a total of 21 days (Benson et al., 2011). Davis, et al. used the DTPT alone and stated the prescribed schedule as approximately seven times a day for a period of six weeks, with evenly spaced intervals (Davis et al., 2011).

The latter two studies remained as consistent as possible with the guidelines from the Wilbargers concerning the stipulated time schedules when implementing the DTPT. Benson, et al. did not specify the time intervals between administering the DTPT at home, while Davis, et al. explained these but did not collect fidelity data to indicate if these times were followed. Furthermore, in both these research studies it was not clearly stated whether administration of joint compressions was adhered to as part of the regime. Use of a sensory diet was only stated in the research of Benson, et al. and Stagnitti et al., which was administered in conjunction with the

DTPT as an additional component used from the Wilbarger protocol (Weeks et al., 2012).

Stagnitti et al. recommended a limited sensory diet to the family during the intervention phase along with the brushing and joint compression regime, administered in the first week, three times a day. This increased in the second week to four to five times a day, as a result of commitment from the parents (Stagnitti et al., 1999). Again, no fidelity data was recorded to describe adherence to the prescribed protocol in the research (Weeks et al., 2012). Co-intervention in this study was explained as four occupational therapy sessions attended after completing the protocol, for which only equipment was mentioned. Following this, the Wilbarger protocol was repeated at five months, administered three times daily for two weeks, though recommended along with behavioural and narrative therapy techniques (Stagnitti et al., 1999).

Modifications to the recommended Wilbarger protocol and poorly controlled fidelity to treatment, along with differences in outcome measures and participant characteristics, make it difficult to collate findings from these studies to strengthen the body of results available. This was confirmed in a recent systematic review, published in 2012, investigating the effectiveness of the Wilbarger protocol on children. Collation of data could not be achieved in this review due to these limitations (Weeks et al., 2012). Additionally, the studies included in this systematic review demonstrate threats to external and internal validity due to methodological flaws. Therefore, findings from available evidence cannot be generalised to the wider population.

All four of these level IV intervention (case series with pre-test/post-test) studies reviewed in-depth in the systematic review, used cross-sectional designs with small sample sizes, meaning that statistical significance of the results could not be calculated (Kimball et al., 2007, Benson et al., 2011, Davis et al., 2011, Stagnitti et al., 1999). The majority of studies published on this topic lack control groups and specific occupational performance outcome measures. The presence of selection bias due to the use of convenient sampling, with investigators not blinded in the selection process, contributes to poor internal validity (Foss et al., 2003). Participants included in the samples were mostly expected to demonstrate positive

responses to the intervention and, in some cases, were selected due to previous positive responses to somatosensory input. Hence, it was more probable that participants selected would benefit from the Wilbarger protocol (Weeks et al., 2012).

The results available from the aforementioned peer-reviewed articles investigating the effect of somatosensory input when provided through the Wilbarger protocol, show that it has been found to be successful in improving both sensory processing and behaviour. Additional studies have reported improvements in social relations, anxiety and temper tantrums (Kinnealey, 1998). The total body of research on this topic includes other literature, such as peer-reviewed conference slides from the 43rd Australasian Society Conference in 2008 on the Study of Intellectual Disability (Chapparo and Mora, 2008), and two abstracts from the 24th Australian Occupational Therapy National Conference and Exhibition, presented in 2011 (Bhopti, 2011, Chapparo and Mora, 2011). Results from the latter conference indicate the study used a high quality randomised controlled trial (RCT) with rigorous implementation of the Wilbarger protocol (Chapparo and Mora, 2011). This study was, in fact, a follow-on from the 2008 presentation by the same authors.

Initially, their study included 16 children (11 males, 5 females) aged 4-10 years (Chapparo and Mora, 2008), which increased to a sample size of 30 participants in the second study using a different range of ages from 6-12 years (Chapparo and Mora, 2011). The study objective, in both cases, was to determine whether administering the Wilbarger (Sensory) protocol as a home-based intervention (Therapressure regime and sensory diet) to children with severe sensory overresponsiveness, would improve their functional performance and behavioural responses. Parents implemented the protocol under the supervision of a trained occupational therapist. A diagnosis of development delay or intellectual disability, with sensory overresponsivity in two or more functional domains (play at school, self-care activities within the home) was indicated. The diagnosis was chosen in light of the evidence that a large majority of the paediatric population diagnosed with intellectual disability presents with sensory overresponsive responses (anxiety and withdrawal) (Chapparo and Mora, 2008, Chapparo and Mora, 2011).

Participants in both studies were randomly assigned to either an experimental intervention - Wilbarger (Sensory) protocol - or a control intervention - behavioural

support - with concealment of allocation stated in the methodology of the second abstract. This RCT crossover design had not been utilised previously in the related research field; neither had statistically significant results for specific outcome measures been reported when comparing this approach to other interventions. The authors concluded that when the Wilbarger (Sensory) protocol is applied in context, with caution and the appropriate training, caregivers are able successfully to use the home-based intervention to achieve positive functional and behavioural gains (Chapparo and Mora, 2008, Chapparo and Mora, 2011). Therefore, the study provides stronger evidence supporting the effectiveness of the Wilbarger (Sensory) protocol for achieving behavioural gains, when used with a population of children with severe sensory overresponsivness. In light of this, a brief account of these findings is necessary.

Statistically, significant differences in functional outcomes between the two intervention groups over two six-week intervention phases was found on the Short Sensory Profile, Developmental Behavioural Checklist, Parent Interview and Sensory Protocol Diary for several variables measured. The initial study differed in that four goal attainment scales were used, and the duration of the intervention period was not stated for this study. Participants in the sensory group still demonstrated greater positive responses measured by behavioural goal attainment scores. Greater decreases in anxiety, as measured on the Developmental Behavioural Checklist, were also found in this group when compared to participants assigned to the behavioural intervention, although no differences were present in total scores on this checklist. Likewise, no differences were found between the two groups on functional goal attainment scores (Chapparo and Mora, 2008).

In the 2011 study, statistically significant differences were also reported in a multiple single-case research study using paired-samples t-test comparisons, with a large effect size found for goal attainment scores. The strength of this research was its treatment fidelity. The whole Wilbarger protocol was administered for a total of six weeks among five boys aged 3-4 years and eligible for early intervention, four of whom had a diagnosis of autism. The protocol was applied daily every two hours, along with prescribed sensory diet activities. Following the intervention process, the children demonstrated reductions in sensory sensitive and sensory avoidant

behaviour, as evidenced by improvements in the quadrant scores for these domains on the Sensory Profile. The improvements were reported to be statistically significant with highest p-values found for scores in these two quadrants, thus strongly indicating a reduction in defensive behaviours and overresponsivity (Chapparo and Mora, 2011).

Two other studies that remain unpublished stated interesting findings related to the use of the Wilbarger protocol (Clark and Ward, 1999). One of these studies, utilising a quasi-experimental design, also included girls in the sample, and although the study could not support the efficacy of the DTPT as a single application, it was concluded that boys respond better than girls after pre- and post-test observations were carried out (Zbytniewski, 2002). The other study, published in a non-peer-reviewed journal as a case study, charted the progress of two boys with sensory overresponsivity. It was determined that one of the boys met all intervention goals six weeks after being introduced to the DTPT during school hours. Interestingly, this was subsequent to a sensory diet trialled for a two week period beforehand, following which the boy continued to display fluctuating attention on-task. The extent of involvement of the Wilbarger protocol in the treatment of the other boy was not clearly explained (Clark and Ward, 1999).

In addition, regarding gender specific findings on this topic, a 3-year old girl was treated for sensory overresponsiveness using the Wilbarger approach over a three-month period. Although, it was stated that the girl displayed fluctuating responses to the DTPT over this period, the case study revealed that improvements were gained overall in the social and behavioural problems related to the diagnosis. However, co-intervention occurred as treatment was primarily based on a sensory integrative approach, with other strategies implemented in the home and clinic environment to provide tactile and proprioceptive input (Kinnealey, 1998).

Response to sensory input and performance in occupations for children with SMD can be facilitated and enhanced by applying sensory processing knowledge within daily life, and through occupational therapy intervention based on a sensory integration (SI) approach (Dunn, 2007). Evidence for the effectiveness of occupational therapy using a sensory integration approach is inconclusive, even though numerous outcome studies exist (Weeks et al., 2012). When using the

Wilbarger protocol within a sensory integration framework, applying it within the context of daily life should be taken into consideration. Segal and Beyer reported certain barriers to parental adherence to the protocol, which were related to the parents perceiving no positive responses to the DTPT and a lack of immediate positive change in the child, as well as the extent to which parents could integrate the frequency of the protocol into their daily lives (Segal and Beyer, 2006). Bhopti indicated positive responses from parents, with most parents finding the use of the Wilbarger protocol assisted their child's participation in daily activities and the protocol was reportedly conducive to family practice principles (Bhopti, 2011).

2.3 CONCLUSION

In summary, the effectiveness of the Wilbarger protocol in regaining and maintaining a state of optimal arousal had not been examined using objective, scientific measures until recently evaluated by a pilot study measuring physiological responses following administration of the DTPT (Kimball et al., 2007). The research appraised in the current debate supports the longstanding, subjective clinical and anecdotal evidence that the Wilbarger protocol successfully decreases negative behavioural responses in children demonstrating sensory overresponsivity to environmental stimulation.

The two randomised controlled studies described, demonstrate the highest methodological quality, and if published in a peer-reviewed journal, would provide significant evidence in support of the Wilbarger (Sensory) protocol. However, in answering the current clinical debate, it is important to note that this is only emerging evidence. The grade proposed by the Australian National Health and Medical Research Council was assessed as "level D" in a recent systematic review considering the best available evidence on this topic to date (Weeks et al., 2012). According to the hierarchy of evidence, this is deemed as the lowest level of evidence (National Health and Medical Research Council, 2009) given that so few studies have been published. Of the studies that have been published, all demonstrate low methodological quality. Therefore, from this evaluation of the peer-reviewed articles available, the body of evidence related to the topic is weak. This implies that for children under the age of 18 years, the Wilbarger protocol should be administered with caution.

CHAPTER 3: METHODOLOGY

3.1 INTRODUCTION

The key constructs related to the methodology of this study will be discussed in Chapter 3. The choice of research design (dependent and independent variables), the process involved in sample selection, as well as the ethical considerations taken into account, will be examined. A detailed description of the measurement techniques and instrumentation used for data collection will be provided. The research procedures undertaken to obtain reliable and valid data will then be outlined, and the management, processing, and statistical analysis of the data will be explained.

3.2 RESEARCH DESIGN

A quantitative, quasi-experimental, cross-sectional design was used to establish the effectiveness of the Wilbarger DTPT in this study. This research design was chosen to investigate the correlations between the independent (DTPT) and dependent (observable behaviours and salivary cortisol levels) variables. Video recordings of behavioural modulation and salivary cortisol levels pre-and-post intervention were assessed. This assessment measured the change in non-desirable behaviours present and in sympathetic arousal of the CNS, directly linked to cortisol levels (de Haan et al., 1998). The changes measured were associated with a single application of the Wilbarger DTPT. The researcher was, therefore, able to assess correlations between the independent and dependent variables (i.e., DTPT with behavioural and salivary cortisol changes) by using this design.

A pre-test post-test design was used whereby the subjects received the intervention and served as their own control rather than using a separate group as the control. Utilising quasi-experimental designs minimises threats to external validity due to the use of natural environments in the research, which, when compared to well-controlled laboratory settings, is less artificial. Since quasi-experiments occur in natural settings, it allows for some generalisations to be inferred to the population, as findings in one subject can be applied to other subjects in similar settings. However, a quasi-experimental design is subject to contamination of results by

confounding variables (Dinardo, 2008). Subsequently, causation cannot be entirely established because extraneous variables cannot be totally controlled by the researcher. Pertaining to the present study variables that were difficult to control that may have confounded results, included the nature and intensity of sensory events the child was exposed to on the day of data collection prior to entering the research environment, which would have differed between participants. In addition, the child's temperament, level of fatigue, sickness or their anxiety related to the unfamiliar situation, group of children and therapists were other variables that could not be controlled. Threats to internal validity also exist due to the lack of random assignment in this design method. Nonetheless, this design was selected for its advantages both in terms of feasibility and practicality, despite being criticised for its lack of a control group in having a single group design.

In this study, the pre-test phase refers to the initial collection of data from which a baseline measurement of participants' behavioural regulation and sympathetic nervous system activity (measured by salivary cortisol levels) was established prior to exposure to the intervention. Observable behaviours within an Activity protocol carried out in a controlled therapy environment, as well as salivary cortisol levels, were pre-test measures. The Activity protocol consisted of a series of "neutral" tabletop fine motor and perceptual play activities including puzzles, pegs, interactive games, mazes, crafts, drawing and perceptual block designs. These were set up in stations for each child to move around to and complete independently. The intervention phase involved a once-off, single application of the Wilbarger DTPT, which each participant received immediately following the initial pre-test phase. The post-test occurred on the same day, directly following application of the Wilbarger DTPT. This was conducted in a similar manner to the pre-test in all aspects, within the same environment.

During the post-test phase the same data was collected to determine the effect of the intervention on the dependent variables, i.e., observable (non-desirable and self-regulatory) behaviour and salivary cortisol. The modified Daily Behaviour Assessment Scale (M Demopoulos, 2009) was used to rate non-desirable behaviours. This scale was taken from a South African pilot study prior to this study, in which it was adapted for the purpose of investigating in-seat behaviour in a

classroom of grade one learners before and after a sensory diet. The scale was further revised for appropriate use in the current study and items measuring self-regulation were added. Behaviours observed in the video recordings before and after exposure to the DTPT were rated on this scale in terms of their frequency. Given that data was collected pre- and post-intervention, allowing comparisons to be made to a baseline measurement, the researcher was able to obtain more reliable and valid data using this research design.

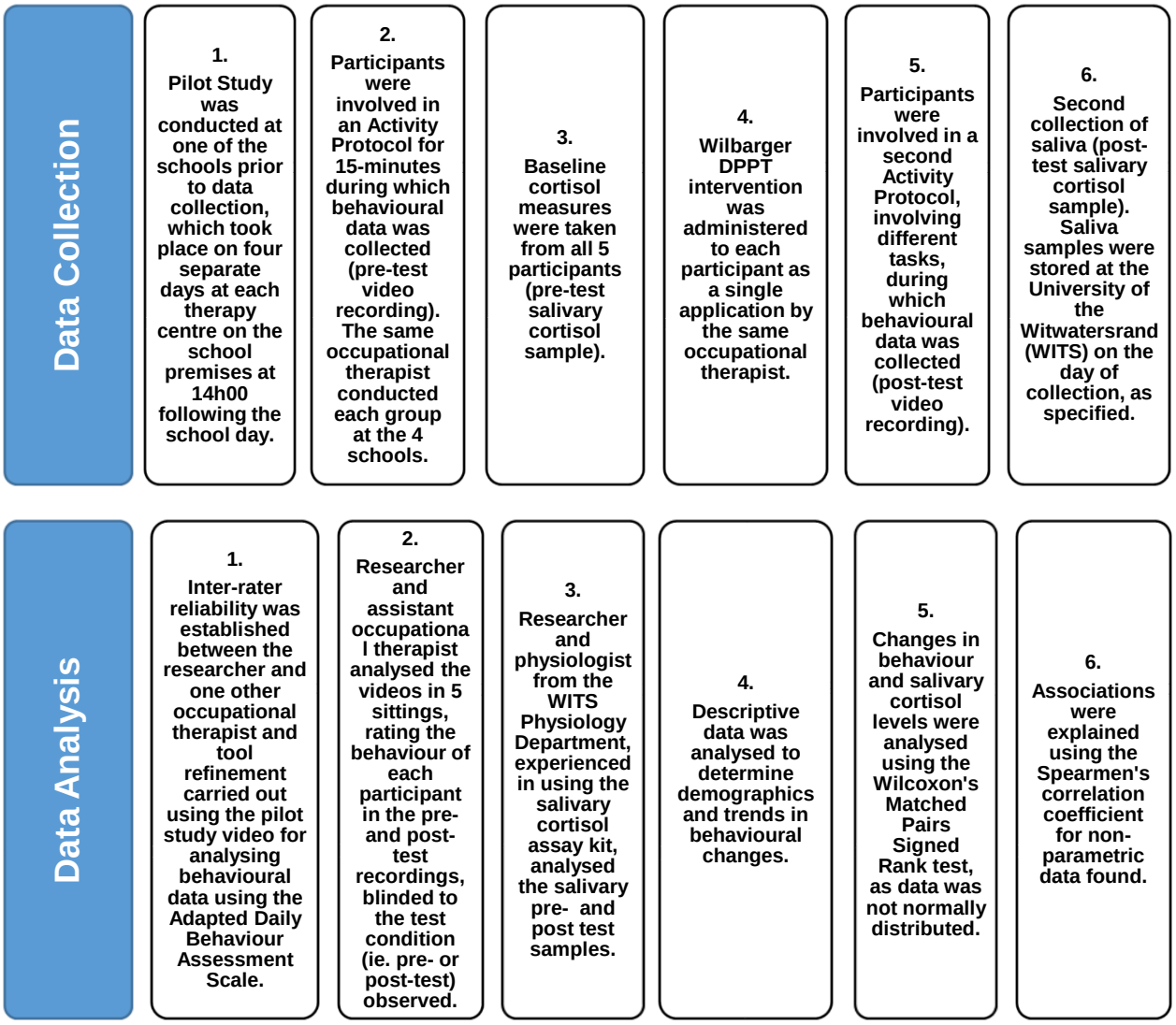

Figure 3.1 Steps followed in the procedure of the study

3.3 SAMPLE SELECTION

Convenience sampling was used to recruit participants for this research study from three different preschools and one primary school located in the northern suburbs of Johannesburg. Permission was first obtained in writing from the heads of these mainstream schools to conduct the study among the learners enrolled in their schools. After this was granted, the researcher approached the occupational therapists treating children in the on-site therapy centres at the different schools. Written permission from each occupational therapist was obtained to use children from their current caseloads at the time.

Participants were selected or excluded from this study on the basis of the following inclusion and exclusion criteria:

3.3.1 Inclusion Criteria

- Age: 4 to 8 years 11 months, currently receiving occupational therapy.

A diagnosis of SMD indicated by:

- the referring occupational therapist based on a Sensory Profile completed with the parent upon referral to therapy (Dunn, 1999).
- the Short Sensory Profile (SSP) (completed by a caregiver upon referral to the study) with scores of ≥-1.5 standard deviations (SD) below normative means for total z scores on one or more of the subtests (Miller et al., 2007d).

3.3.2 Exclusion Criteria

- Any child who had not previously received the Wilbarger DTPT during therapy and/or as a home programme.
- No known current psychiatric disorders on the DSM-V, if formally diagnosed by a psychiatrist previously and confirmed by the treating occupational therapist, and no clinically apparent disorder.

The occupational therapists at the centres identified suitable children with sensory modulation dysfunction, confirming whether or not a current co-morbid diagnosis made by a psychiatrist had been indicated. Children who met the specific inclusion criteria, without fulfilling any of the exclusion criteria defined, were invited to

participate in the study. Learners were recruited for this study from Grade 00 up to Grade 3.The participants included 9 females and 12 males and ranged in age from 4 years to 8 years 11 months. Although participants' SSP scores were used for their inclusion in the study, their Sensory Profile (SP) scores and quadrant classifications were also analysed at the time of data analysis. These SPs were obtained from the treating occupational therapist of each child and were their most recent profiles completed by the parents.

3.3.3 Sample Size

Reported in the findings of a pilot study conducted by Schaaf, Miller, Seawell and Keefe (2003) using a post hoc power analysis, was that a sample size of 20 participants would yield an estimated power of .96 for studies investigating autonomic nervous system functioning (Schaaf et al., 2003). Thus, a sample size of 21 participants was recruited for the present study, as determined by previous research to be an adequate size for effectively detecting a difference between pre- and post-test measures (calculated with power .90 and alpha at .05). The additional participant was included in the study to deal with the possibility of drop-out from the study or the likelihood that data could not be used for any given participant.

3.4 ETHICAL CONSIDERATIONS

Study procedures were approved by the Human Research Ethics Committee at the University of the Witwatersrand (Appendix A). Permission was granted by the principals of the respective private schools (Appendix BI-III) and the occupational therapy practices (Appendix CI-II) after an informative letter was sent (Appendix BIV and CIII). An information document was distributed and explained to parents or legal guardians prior to the study (Appendix D).

Participation in the research was entirely voluntary, for parents and children, with no costs incurred. Informed consent for potential participation in the pilot study and for inclusion in the main research study (Appendix D) was obtained in writing from the parents of each child. In addition, the parents were required to give signed consent to grant permission for collecting saliva and videotaping their child (Appendix E and F). The children were given a detailed, age-appropriate description of the steps involved in the study (approved by the Ethics Committee prior to commencement of

the research) and asked to give verbal assent and signed consent (where applicable to their ages) to participate in the research (Appendix G). This was witnessed for all the children by one other occupational therapist in each referring practice. Special care was taken to ensure that both the parents/guardians and children understood the details provided in the information sheets pertaining to the study. The researcher made telephonic contact with each parent/guardian before assent was given in an effort to ensure they were aware of all the steps involved.

Confidentiality was ensured throughout the study, as no names were used in the data collection process. Rather, participant codes were assigned as a number that became their identification throughout the research. No potential risks were involved, given that each participant recruited for the study's procedure had previously received or was currently receiving the Wilbarger DTPT in occupational therapy and/or as a home programme. As stipulated by the Ethics committee any child who had not previously received the protocol had to be excluded from the study to prevent unforeseen harm to any child from first time exposure. However, no direct benefit could be expected for the participants receiving the intervention, as it was administered once-off in the study's procedure. Parents/guardians were informed that feedback from the study would be made available on request. Videotapes and saliva samples/assays are stored together at WITS university, to which only the researcher has access (for a period of six years or for two years after publication).

3.5 MEASUREMENT TECHNIQUES AND INSTRUMENTATION

3.5.1 Short Interview Questionnaire (Appendix H)

A questionnaire to obtain demographical information and details related to the Wilbarger DTPT previously or currently used with the child was obtained prior to initiation of the study. Parents/guardians were requested to complete a short interview questionnaire to obtain demographical and medical data (e.g., sex, age, any current medication, sensory modulation difficulties, and reason indicated for referral to occupational therapy). In addition, they were asked to describe their child's general behaviour in the home environment and explain their experience and observations of the effect of the Wilbarger DTPT when used with their child. With the data collected from these parent questionnaires, internal and external

extraneous factors were accounted for (e.g. child's specific sensory processing difficulties, anxiety levels, emotional state, presence of life stressors and the length of previous exposure to the Wilbarger protocol) when comparing the participants' responses to intervention as described by the parent, with the actual research data.

Details regarding the child's social, scholastic, and developmental history were also taken into account when analysing the data. Sensory integrative dysfunction is strongly associated with genetic as well as biological factors and is secondary to psychological stress (Dunn, 1999, Schaaf et al., 2010b). Thus, information related to each child's developmental history, genetic and biological factors was important to ascertain at the onset of this study for means of analysis and comparison later on, as well as for controlling those extraneous influences that could possibly have impacted results.

3.5.2 Sensory Profiling

The Short Sensory Profile and Sensory Profile are standardised, caregiver-report questionnaires used as screening tools to measure functional behaviours associated with abnormal responses to sensory stimuli. Standard practice in paediatric assessment involves the use of either of these two profiles for identifying sensory processing disorders where sensory modulation is specifically assessed. These tools are accepted and understood among therapists working with this population.

Although these tools have not been standardised in the South African population, they are considered to be valid and are widely used in the field of paediatric occupational therapy, and will remain so until a suitable alternative South African tool is found, if needed. The behaviours linked to SMD are observed within different categories, which differ between both profiles. The SSP was designed by Miller and her colleagues for use in research, as it is a shorter version of the SP and was intended to aid researchers and clinicians in effectively identifying children with or without SPD (Dunn, 1999). Both the Short Sensory Profile and the Sensory Profile are used as standard diagnostic methods for evaluating the child's responses to specific sensory events (Kimball et al., 2007).

The SSP together with the SP was used to classify children for this research using their profile of scores. The classification system organises them into three separate groups based on the performance of a sample of children without disabilities (n=1037). “Typical” sensory processing is indicated by scores at or above point 1 SD below the mean, while “probable differences” are noted by scores at or above point 2 SD below the mean, but lower than 1 SD below the mean. “Probable differences” signify only questionable areas of sensory processing abilities in the child whereas “definite differences” indicate the child has a problem and show marked sensory processing difficulties when the score is below point 2 SD below the mean (Kielhofner, 2006, Dunn, 1999). These classifications were used in profiling the child’s sensory systems for inclusion in this study and to identify sensory overresponsivity in one or more of the participants’ sensory systems.

The SSP was completed by the caregivers upon participants’ referral to the study to determine their sensory processing patterns at baseline. In addition, the treating occupational therapists completed SP’s in consultation with the parents at the time when their child commenced with therapy. These were referred to for each child in the study and used in conjunction with the SSP to assess participants’ primary presenting problems, even though categories differ slightly between profiles the information yielded is similar, yet the SP is more indepth. This step was taken because the researcher found that due to the SSP form being used for research purposes only and in no way was it used to benefit the child’s therapy, parents did not see the importance of it for their child and as a result did not take time to complete it accurately. The occupational therapists were then consulted to ensure information obtained on the SSPs provided a realistic picture of each participant’s SMD. This was not the case for 29% of the participants where the therapists felt the caregiver-reported information was incomplete, despite all participants qualifying for the study according to inclusion criteria related to their SSP scores.

3.5.2.1 Short Sensory Profile (SSP) (Appendix Ia) (R. Ahn, L. Miller, S. Milberger, & D. McIntosh, 2004; W Dunn, 1999b; D. McIntosh, Miller, Shyu, & Dunn, 1999a)

The SSP was developed specifically to assist in identifying children with SMD, differentiating between responsivity levels and distinguishing these children from typically developing children of the same age. The screening instrument was

developed from extensive research and development on the Sensory Profile. Internal reliability of the Short Sensory Profile total test is well-established (.95). Inter-correlations between the total test scores and section scores yielded results that were significant for all correlations ($p<0.01$) among a sample of children with and without disabilities (calculated using Cronbach's Coefficient Alpha). Inter-scale correlations were moderate and ranged from .25 to .76 across three different samples, indicating that subscales reliably measure unique dimensions (McIntosh et al., 1999a).

Children with SPD were compared to a group (n=38) of age and gender matched typically developing children to establish discriminant validity. Discriminant validity was found to be high (>95%), where the group with SPD scored significantly lower than the typically developing group on the SSP. Furthermore, physiological evidence of SPD was compared to Short Sensory Profile scores to establish convergent validity, where abnormal electrodermal reactivity in response to sensory stimulation was significantly associated with atypical scores on the Short Sensory Profile.

The SSP was used for inclusion of children in this research study and took approximately 10 minutes for each parent/guardian to complete. A Likert-scale is used in the SSP to rate the frequency with which the child exhibits atypical behaviours (never, seldom, occasionally, frequently, always) to 38 different sensory events grouped into 7 different aspects including: (1) tactile sensitivity (2) taste or smell sensitivity (3) movement sensitivity (4) underresponsivity/sensation seeking (5) auditory filtering (6) low energy/ weakness (7) visual/ auditory sensitivity. An overall classification of "typical performance", "probable difference" or "definite difference" is used to establish where the child's sensory processing abilities fall, according to the scores obtained for each section (i.e., "never" receiving 1 point and "always" receiving 5 points).

3.5.2.2 Sensory Profile (SP) (Appendix Ib) (Dunn, 1999)

The Sensory Profile is a tool designed to evaluate children's responses to commonly occurring sensory events in daily life and consists of sensory history items reported in the literature. The 125-item scale provides a standardised method for assessing behaviours and their sensory basis. Parents use a 5-point Likert-scale to report the

percentage of time their child engages in each behaviour. Data derived from the Sensory Profile shows how patterns in sensory development may contribute, or create barriers, to participation in daily life. Scores obtained on the Sensory Profile for each child can be compared to the performance of a national sample of children without disabilities (n=1037), ranging in age from 3 to 10 years. Internal consistency was used to estimate the reliability of the Sensory Profile. Cronbach's Alpha was calculated to examine the internal consistency for each section of the Sensory Profile and ranged from .47 to .91. The content validity of the Sensory Profile is reported at 63% and a moderate rating is indicated for construct validity (Schaaf and Nightlinger, 2007).

Dunn's theoretical model of sensory processing was used in this research to organise children into separate quadrants for analysis of the data. The quadrant(s) into which each child falls is determined by Sensory Profile scores and based on neurological thresholds and response patterns to sensation. In the presence of a low neurological threshold, nervous system responses to sensory stimuli are more frequent because it does not take much input to reach the threshold. However, with high neurological thresholds, the nervous system does not respond to sensory stimuli because they need much more input to reach their threshold, in order for registration to take place.

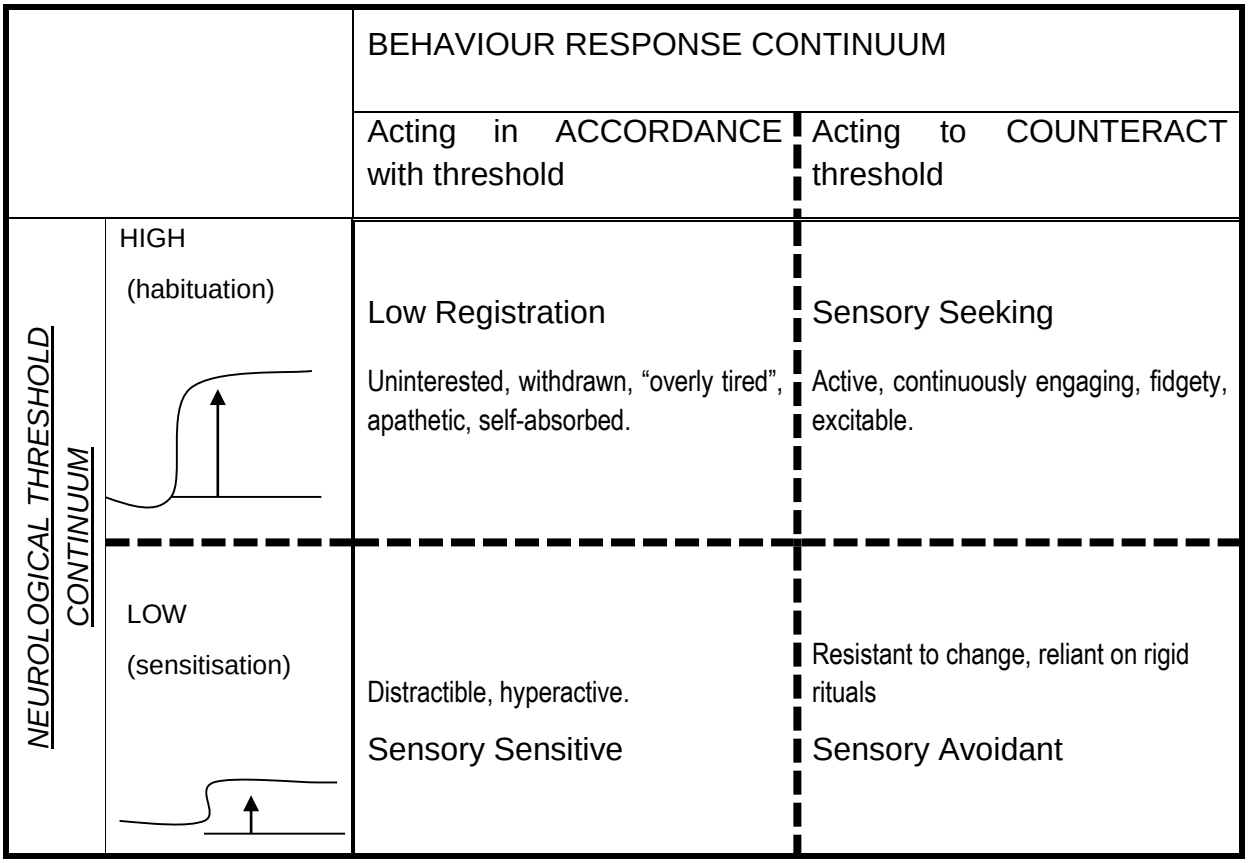

Figure 3.2 Interpretation using Dunn's theoretical model of sensory processing and quadrant classification Page 34: (Dunn, 1999)

Children with high thresholds may, therefore, have a dormant system (responding in a passive way for most of the time) or may seek sensory input to counteract their thresholds. Children with low thresholds may display sensitivity to stimuli (acting in accordance with their thresholds) or display sensation avoidant behaviour (acting to counteract their thresholds). However, these response patterns and behaviours may co-exist and a combination may be exhibited by the same child. Responses along these continua interact to create four quadrants of responsivity (Figure 3.1). Functional performance is reliant on a balance between activation of responses and filtering of stimuli for a child to be alert to selected stimuli but also able to screen out irrelevant stimuli (Dunn, 1999).

3.5.3 Adapted Daily Behaviour Assessment Scale Revised (Appendix J)

Participants' behaviour was recorded on video and evaluated by rating the frequency of specific behavioural observations on the Adapted Daily Behaviour Assessment Scale (M Demopoulos, 2009). The scale was originally developed by

an occupational therapist and was based on various behaviour assessments (Edwards, 1986). The items on this scale describe non-desirable behaviours that can be expected from children with SMD and were, therefore, sensitive in measuring the anticipated change. The original scale from 1986 was used in a more recent South African study in 2009 and, in both cases, the scale assessed eight areas of behaviour including concentration and attention, behaviour in group situations, perseverance and task completion, organisational ability, ability to cope with new situations, social interaction, responsibility and initiative, and emotional control (Demopoulos, 2009).

The assessment scale was revised for the purpose of this research through expert-jury validity. Given that the scale was intended to assess a child's ongoing classroom behaviours to gauge the effect of therapy, certain items were removed that were specifically related to the classroom, or which were better measured over time (i.e., not appropriate for measuring a short term change). A pilot study was carried out prior to the main part of this research for the purpose of developing the correct measurement tool derived from the Daily Behaviour Assessment Scale. Three experienced SI certified professionals were asked to mark the most overt behaviours displayed by participants in the pilot study.

Pilot studies aimed at development of an instrument or intervention frequently use an expert jury (Bailey, 1997). According to ratings recorded by the expert-jury during the pilot study, the items on which no ratings were marked across all five participants were disregarded from the scale for the main research. The most overt behaviours observed across participants in the 15 minute pre- and post-test period were 20 out of 31 items. The category, emotional control, was removed and a new category, self-regulation, was added. Overall, a total of 11 items was removed from the scale but 12 items were added, with 3 of these additional items being added to the new category of self-regulation. Scoring recorded the number of times the behaviour was present on each item during the time the child was observed (i.e., in a period of 15 minutes).

The Adapted Daily Behaviour Assessment scale was selected due to no other standardised behavioural scale being published to date. From other limited, non-

standardised scales available, this was most appropriate having been field-tested in a recent South African study (M Demopoulos, 2009).

3.5.4 Video Recordings Pre- and Post-Test

During the pilot study, the Daily Behaviour Assessment Scale was revised and inter-rater reliability was established between the researcher and one other occupational therapist. The two independent processes conducted during the pilot study phase involved two separate groups of occupational therapists. The first group consisted of three external occupational therapists who watched the pilot study video to adapt the Behaviour Scale.

Following this initial step, the researcher and one other independent occupational therapist also observed and evaluated the pilot study video recording. Through this process, inter-rater agreement (i.e., the percentage of observational units agreed upon by both observers) was established. The process of observing and evaluating the pilot study video was completed by the researcher and occupational therapist observing five children and rating their behaviour on the revised Daily Behaviour Assessment Scale. Their recorded ratings for each child were compared and their observations discussed. Therefore, consistent inter-observer agreement was established preceding scoring of the actual video recordings for the research.

The pre- and post-test video tapes were each randomly assigned a number prior to evaluation of the raw data. The observers were blinded as to which phase of the research (i.e., pre- or post-test) the video was taken and concealment was adhered to throughout. The intervention procedure relates to the theory of the sensory integration framework. Thus, the expert jury and external observer rating the actual research videos needed to have experience with this theoretical background and with child development theory, for accurate observation to be logically related to the overall framework. The external occupational therapists who were selected, all had at least five years of experience in paediatrics, with a certification in sensory integration. The experience of these therapists enhanced the accuracy of video observations and promoted construct validity from the dichotomous data obtained.

3.5.5 Enzyme-Linked Immunosorbent Assay (ELISA) Kit Manufactured by Salimetrics LLC

Specific steps were followed to ensure accurate collection of saliva, as outlined by Salimetrics (Appendix K) (Salimetrics, 2012). Salivary cortisol levels are regarded as a reliable estimate of serum cortisol levels because studies consistently show high correlations between salivary and serum cortisol levels (Lumley et al., 1995, Schmidt, 1997). The enzyme-linked immunosorbent assay (ELISA) is one of two types of tests used to determine salivary cortisol levels and has a significant correlation ($r(47)=0.91$, $p< 0.0001$) between saliva and serum.

Salivary assessment of participants' cortisol was the preferred method selected, given its advantages over blood and urine sampling. Cortisol concentrations in saliva do not depend on salivary enzymes or salivary flow rate and are directly proportional to blood concentrations. Research has shown that sympathetic arousal of the CNS is directly related to cortisol levels. Therefore, sympathetic nervous system activity could be effectively measured by analysing the change in participants' cortisol levels after the post-intervention phase (Schmidt, 1997, de Haan et al., 1998).

The ELISA test can be done without radioisotopes and requires small amounts of saliva. Although cortisol levels rise in response to stressful stimuli, this is independent of the peak in cortisol production following a circadian rhythm. Highest values of glucocorticoid levels are recorded after awakening, reducing to half of morning levels in the late afternoon and dropping to the lowest levels, at which almost insignificant values are found by midnight (Miller et al., 2007a, Clow et al., 2010).

Therefore, saliva was collected at 14h00 in the afternoon for all groups in the research ensuring consistency in cortisol levels. This time of day is when cortisol levels are most stable, as lower concentrations of cortisol can be found at this time of day. Therefore, the researcher controlled for the peak in cortisol production by obtaining cortisol samples at a time of day when cortisol levels have stabilised. The initial collection of saliva was used as a baseline measurement that was then compared to the second collection of saliva taken post-intervention. Analysis was performed by the researcher, assisted by the Faculty of Health Sciences Physiology Department using ELISA, a product of Salimetrics. The amount of cortisol in each

sample is based on an optical density value, which is determined by a spectrophotometer. There are no available norms for cortisol levels in saliva (Kimball et al., 2007).

Participants were asked to rinse their mouths out with water immediately before entering the research environment at the start of the session. In order to encourage the children to produce enough saliva we asked them to pretend that they were brushing their teeth. We did this in front of a bathroom mirror and provided them with a real toothbrush, although this remained dry and no water was used. This step in the research was based on the method used in the study by Kimball et al., as it relates more to the children's immediate occupational experience. Once they had pretended to brush their teeth they were then asked to spit into the plastic specimen bottles, which were purchased from the pharmacy.

3.6 RESEARCH PROCEDURE AND DATA COLLECTION

3.6.1 Pilot Study to Validate and Revise the Daily Behaviour Assessment Scale

Since the Daily Behaviour Scale is not a standardised assessment, a pilot study was carried out to determine the content validity of the scale. From this, the items were revised for the purpose of this research. Refinement of this tool ensured that the richest, most meaningful data was extracted for the study. The pilot study was similar to the actual research in all aspects except no saliva samples were taken from participants. Five children who met the inclusion criteria for the main study were recruited from a site different to those used in the main research. Parents were given the same information document regarding the research and were told afterwards whether their child was in the group selected to be used for the pilot study or whether they were included in the main research.

For the parents of the children randomly selected for the pilot study, the same informed consent sheet was signed. In addition, a separate document was obtained providing consent for their child to be videotaped and observed by a panel of occupational therapists (Appendix F). Verbal assent was also gained from each child (Appendix G) before inclusion of these five participants in the pilot study. During the pilot study, the research environment was simulated without collection of saliva

samples. Specifically, the same therapists and conditions were used and video recordings of behavioural modulation were taken during two consecutive 15 minute sessions. Participants were engaged in an Activity protocol similar in all aspects to the activities used in the main research.

Three occupational therapists, experienced in the field of paediatric learning disabilities and with qualifications in sensory integration, were asked to observe the videos and complete the Daily Behaviour Assessment Scale for all five participants. This involved a panel discussion among themselves, reviewing the way in which they observed and rated every behaviour displayed by each participant. Once all participants' behaviours were rated, a focus group discussion was held for the expert panel to discuss and identify relevant items from the total scale. Only the behaviours observed and, therefore, scored across all five participants were included in the revised version of the scale. The behaviours that did not receive any rating were removed. This ensured that the items required for accurate assessment of behaviours - those that would most likely be displayed by participants during participation in the Activity protocol - were part of the scale. The wording of certain items was changed, though this did not alter the content of the item and the aspect of behaviour measured by this item, relating to a specific category. The items added were only behaviours that had been observed in all five participants across the group.

After expert panel discussion, it was decided that a separate category measuring self-regulatory behaviours be added. The scale failed to assess adequately these behaviours, which were displayed repeatedly by participants in the pilot study. According to theory, a child who seeks sensory input can often become over-aroused in their pursuit of the input that they seek (due to craving it in excessive amounts). However, another child may appear to need sensory input as well but uses this input in order to self-regulate and thus remains in a state of optimal arousal. This is often referred to in the literature as an individual's range of optimal performance (Kimball et al., 2007). It is important to note this difference between sensory seeking behaviour and seeking sensation in order to self-regulate, as the two were differentiated in this study. This conceptualisation allows a distinction to be made in order to identify the exact nature of behaviour observed. Self-regulatory

behaviour (seeking sensory input to remain calm, organised and alert) was rated in the category added to the scale for this research, as agreed upon by the expert panel.

The self-regulation items added to the behaviour scale were intended to measure each participant's ability to remain within their optimal level of arousal or range of performance during the Activity protocol. The Wilbarger DTPT was not designed to treat sensory seeking but rather sensory sensitive (defensive) behaviour. In cases where this behaviour appeared more as sensory seeking it was not rated as self-regulation (i.e., behaviour causing the child to become over-aroused or disorganised, failing to remain on-task). In order to distinguish behaviour as sensory seeking rather than self-regulatory, participants' sensory profiling was also taken into account for accurate assessment of what was seen.

When a participant displayed sensory seeking behaviour that caused him or her to become over-aroused during the Activity protocol, this was recorded by rating other more specific items that described the consequences of his or her sensory seeking behaviour. These included the participant getting out of his/her seat, displaying a need to move around, being disorganised in self, and in his/her work, showing a lack of planning in work, disrupting the group and disturbing others, making transitions between tasks without completing the given task, working too fast, and exhibiting restless, overactive and impulsive behaviour.

3.6.2 Data Collection: Behaviour and Salivary Cortisol Levels Before and After the Intervention

This study was conducted during the period of September 2012 at four different private schools in the on-site therapy centres. Data collection took place on four separate days at each therapy centre attached to the schools. Behavioural data and saliva samples were collected from 21 participants in the pre- and post-test phases of the research with participants divided into three groups of five participants and one group of six participants. Behavioural data was collected by means of three different video cameras positioned to capture each of the three activity stations where participants were seated at desks. Saliva was collected in specimen bottles, into which participants were asked to spit directly.

Data collection commenced at 14h00 for all groups. This time was decided upon because cortisol concentrations in saliva are most stable in the afternoon (i.e., lower concentrations found). At this stage, participants would have completed their school day involving normal activity within their natural environment, therefore accounting for "stress" levels they would usually be exposed to on a normal day. Typically, children with SMD struggle to cope with the normal routines of daily life. Those with sensory overresponsiveness specifically cannot cope. After exposure to many competing sensory inputs within the multisensory classroom environment these children often reach sensory overload. Therefore, the child's behaviour and level of arousal may be carefully observed at this time of the day, given the sufficient amount of time for exposure to sensory stimulation to occur within his or her natural environment and to build up in his or her nervous system.

The pre- and post-test data were collected on the same day for each participant. This involved two successive 15-minute video-recorded group sessions (pre- and post-test) where participants were involved in the Activity protocol with a break of 15 minutes in between. The break was used to administer the DTPT to each participant, one at a time, by the same occupational therapist for all groups. This also allowed for enough time for cortisol to express itself in participants' saliva, taking up to 15 minutes after exposure to a stimulus.

3.6.2.1 Obtaining Permission and Sample Recruitment

Once written consent was obtained from the head of each school and occupational therapists at the on-site therapy centres, the head occupational therapist at the centres identified suitable children with sensory modulation dysfunction. It was first confirmed whether any current co-morbid diagnosis had been indicated by a psychiatrist. Information sheets, informed consent forms, and demographic questionnaires were then sent home to the parents/legal guardian of each child identified as being a possible participant. Following this, the researcher contacted those parents that agreed to participate in order to clarify all details outlined in the information document, taking special care in explaining the ethical aspects described.

Once informed consent forms were signed, all parents were requested to complete the SSP. It was explained that their child's inclusion in the study was dependent on

his or her scores on the SSP. The children whose scores on the SSP reflected those defined in the inclusion criteria for SMD and who met all other inclusion criteria were grouped together as possible participants for the study. Following this procedure, a sample was selected of different ages (4-8 years), including 21 children for the research study. The SP was obtained from the occupational therapists' records for each child once permission was granted by the parents.

3.6.2.2 Pre-Test Phase (Baseline Measurement)

The Activity protocol, as implemented in a previous study (Miller et al., 2007d), is considered to provide types of activities that do not target problems related to those being measured. A range of "neutral" tabletop play activities such as puzzles, blocks, interactive games, drawing, arts and crafts, and reading stories was used. All participants were involved in the Activity protocol and were videotaped for 15 minutes (pre-test recording).

The occupational therapists supervising the Activity protocol were the same two clinicians for all groups. Their role in the group was passive. They mainly assisted children when they needed to transition from one activity to another but only when the child indicated that they were ready or asked to move to a different activity station. They intervened or provided help with an activity when specifically requested to do so by participants.

The initial saliva collection, taken after the first 15-minute group session, was used as the baseline cortisol measurement (pre-test cortisol sample). Two other assistants who were staff at each school and familiar to the children, aided in this process to allow all participants to spit at the same time. The specimen bottles with saliva samples were immediately labelled with the child's participant code and directly placed on ice and frozen.

3.6.2.3 Intervention

The Wilbarger DTPT (Appendix K) was administered to each child by the same occupational therapist once saliva samples were collected as the baseline measurement. The DTPT is designed to be used every one and a half to two hours during daylight hours. However, a single application of the Wilbarger DTPT was adequate for the requirements of this study, as only an immediate response was

measured to investigate the associated short-term behavioural and sympathetic nervous system changes in participants. Extraneous variables were, therefore, controlled in the research environment. Furthermore, a new therapressure brush was used for each participant and while participants waited for their turn to be brushed, they remained sedentary on the carpet having a story book read to them.

3.6.2.4 Post-Test Phase

The second group session was similar to the first in all aspects except the tasks used. These were changed from the pre-test phase to introduce a new range of “neutral” tabletop play activities. The Activity protocol, therefore, differed from the pre-test in that participants were unfamiliar with the new tasks that were introduced and videotaped (post-test recording). The activities selected for the first group session were mimicked in the second group session but differed in order to prevent participants feeling bored, which would have impacted their behaviour. Specifically, the activities had the same requirements but the pictures, objects, materials and boards were changed. This brought in an element of variation in order to avoid negative behaviours being displayed by participants due to boredom with activities that were familiar or had already been completed. The supervising occupational therapists were again present merely to facilitate the group process and direct participants when they were ready to move on to a different activity. The second collection of saliva (post-test cortisol sample) followed the 15-minute Activity protocol session. After this, cortisol changes that occurred from administering the DTPT had sufficient time to reflect in the saliva of participants. The specimen bottles were labelled with participant codes and each marked with a capital ‘A’ to identify them as the post-test samples. The bottles were kept on ice and taken to the freezer at the university directly after every group session.

3.6.3 Control of Extraneous Variables

Throughout the research process, efforts were made to control all extraneous variables or to keep additional factors constant that could have potentially influenced the results.

Age, sex, diagnosis, medication, nutrition, body weight, life stressors at the time, and previous or present exposure to the Wilbarger DTPT were all important

variables that could have confounded results. Specifically, research from Kiess et al. (1995) states that cortisol production increases with body weight but no sex or age differences (after 12 months old) are found in salivary cortisol levels (Kiess et al., 1995). These variables were taken into account by obtaining demographical information from a parent questionnaire. Furthermore, any child who had not previously received the Wilbarger DTPT during therapy and/or as a home programme was excluded from the study.

An experienced clinician who had received specialised training in the Wilbarger DTPT administered the intervention to all participants and another occupational therapist assisted her in supervising the Activity protocol. These two therapists remained the same throughout the study.

Variables that could possibly have influenced the measurement of cortisol in saliva included certain foods ingested, specific medications taken, and the time of sample collection during the day. A list of specified foods is contra-indicated when using the ELISA, for the potential of these foods to produce false results. This is unless sample collection of saliva was taken 60 minutes after ingesting a major meal or by rinsing the mouth thoroughly with water 10 minutes prior to sample collection, as stipulated by Salimetrics, LLC (Salimetrics, 2012). These measures were taken to control this variable in the study. None of the participants in the study were taking any stimulant medication or other psychotropic drugs. All participants were included in the research on the basis of having no co-morbid psychiatric diagnosis at the time of the study, as the drugs used in the treatment of such conditions often interact to cause unreliable results when measuring cortisol concentrations in saliva.

The time of day that samples were collected could have affected results due to diurnal variations of cortisol levels in saliva (Lane et al., 2010). Thus, all samples were taken at the same time for all participants in the early afternoon due to cortisol levels being most stable three to nine hours after awakening (Clow et al., 2010, Lane et al., 2010, Edwards et al., 2001) and to allow enough time after a meal had been ingested. Sufficient time was allowed for changes in participants' cortisol to express itself in their saliva. The Activity protocol was conducted in between collection of baseline and post-test samples because changes in cortisol levels take

approximately 15 to 20 minutes to peak in saliva after being exposed to a stimulus (Schmidt, 1997).

Importantly, cortisol was measured before and after engagement in normal activity in a natural environment, a limitation for which the previous pilot study did not account (J. Kimball et al., 2007). In addition, familiar activities were incorporated into the Activity protocol carried out in the on-site therapy centres where the child attends weekly therapy sessions. The research was conducted on a school day ensuring that normal routine, as well as stressful situations typically experienced during a school day, were taken into account.

Video recordings were analysed by the researcher and one other occupational therapist, completed over five sittings. The behaviour of participants was rated in the pre- and post-test videos on the Adapted Daily Behaviour Assessment Scale (M. Demopoulos, 2009). The order in which the pre- and post-test videos were observed varied according to random selection, and was unknown to the observers who remained blinded to each group session. Inter-observer agreement was established before rating the test recordings. The saliva samples were stored as specified (Appendix L) and analysed by the researcher and a physiologist from the University of the Witwatersrand (WITS) who was experienced in using the salivary cortisol assay kit in previous research conducted among a larger sample (n=250), ensuring the analysis was accurate. The cortisol was measured by obtaining a mean value from two measurements taken from the saliva assayed for each participant, for both the pre- and post-test.

3.7 DATA ANALYSIS

Descriptive data was analysed to determine demographics and trends in behavioural changes. Quantitative data were collected and complied in Excel spreadsheets and analysed using Statistica v 12. The behavioural data is presented as means and standard deviations of behaviours observed during the measurement period prior to the intervention and post intervention (i.e., 15-minutes pre-test and 15-minutes post-test). This pertains to both the items with significant change and the items where four or more observations were made and analysed using the Wilcoxon’s Matched Pairs Signed Rank test for non-parametric data. This test was

used due to the small sample size and because data was not normally distributed with ordinal scales. The items with four or less pre-test or post-test observations were not analysed. The small number of observations for these items did not allow enough variation for statistical analysis and represented the behaviour of less than 20% of the participants in the sample. Because the number of observations for different items varied, the effect size for the items with more than four observations, either pre- or post-test, was also calculated. Clinical significance can be inferred from effect sizes. This is important since clinical significance can be considered as moving the participants into a functional range and is, therefore, also important in terms of outcomes of the intervention in this study (Jacobson and Truax, 1991).

The categories made up of individual items were then analysed as a whole using the findings from all items in the scale where behaviours had been observed, even if only one observation was made. Descriptive means and standard deviations were used from the Wilcoxon's Matched Pairs Signed Rank test for non-parametric data. Effect sizes were also calculated to determine clinical significance.

The change in self-regulatory behaviours was considered separately. The items included in this category cannot necessarily be considered as negative behaviours. Thus, the items and category of self-regulation were analysed by describing the change in sensory input (i.e., the amount and intensity) needed to self-regulate and the change in the category overall, with effect sizes reported.

Changes in salivary cortisol levels were also analysed using the Wilcoxon's Matched Pairs Signed Rank test. The data was divided into three groups for analysis - those with an increase in cortisol levels, those with a decrease in cortisol levels and those whose cortisol levels remained the same. Participants' baseline cortisol levels were also compared between these three groups, assessing baseline levels for the group with a decrease in cortisol levels and for those who had an increase or no change in cortisol levels.

The reduction in negative behaviours of the participants who presented with definite tactile sensitivity and touch processing difficulties was compared to those who had no or probable tactile sensitivity and touch processing problems. The Mann Whitney U test was used to compare these two groups, who were differentiated in terms of their behaviour and cortisol levels.

Associations between the difference in negative behaviours and the difference in cortisol levels were determined using the Spearmen's correlation coefficient for non-parametric data.

3.8 CONCLUSION

A quantitative, pre-test post-test quasi-experimental research design was used on a convenient sample of 21 participants in this study. The individual differences in behaviour and salivary cortisol levels were explored prior to and following exposure to a single application of the Wilbarger DTPT. The results of these findings are presented in the next chapter and provide an indication of the short-term modulating effect of the Wilbarger DTPT on behaviour and autonomic nervous system responses in children from the general population. These were children exhibiting over-and underresponsivity to stimulation, as differentiated by their Sensory Profiling (SSP and SP scores). Findings explaining the effect of the DTPT on sympathetic nervous system activity, measured using the ELISA to analyse cortisol concentrations in saliva, are correlated with scores of behavioural modulation, measured on the Daily Behaviour Assessment Scale. This scale was revised for the purpose of this research in a pilot study conducted prior to commencement of the research study.

CHAPTER 4: RESULTS

4.1 INTRODUCTION

This chapter lays out the results of this study evaluating the effectiveness of the Wilbarger DTPT, in changing behaviour and salivary cortisol levels (sympathetic arousal), after a single application to 21 children with SMD. Behavioural data was analysed for 21 participants (n=21), whereas cortisol results were yielded for a sample of 20 participants (n=20), with one child removed from this analysis due to extreme values being recorded.

Section 4.2 describes the baseline data for the subjects studied. This includes an examination of the demographics and sensory profiling of participants. Thereafter, a comparison will be drawn in Section 4.3 between participants' behaviour (negative and self-regulatory behaviour) and salivary cortisol levels before and after the intervention.

Section 4.4 will further examine these dependent variables by considering whether or not an association exists between the changes noted in behavioural modulation and salivary cortisol levels as we expect to find for each child. A discussion regarding whether or not the null hypothesis is accepted or rejected concludes this chapter.

4.2 DEMOGRAPHICS

Table 4.1 depicts the basic demographics of the sample recruited for this study. The participants, who ranged in age from 4 years (4:0) to 8 years and 11 months (8:11), included 9 females (43%) and 12 males (57%).

None of the participants were diagnosed with a known psychiatric diagnosis according to criteria from the DSM-V prior to inclusion in the study. All participants had been referred with SMD by the treating occupational therapists. From the parent questionnaire it was reported that 9 participants were still using the Wilbarger DTPT at the time of the study and all other participants had been exposed to it or used the protocol at some point in their treatment process prior to data collection. Caregivers were asked to indicate whether their child presents with performance or generalised anxiety symptoms. Although not formally diagnosed, 43% responded yes,

describing definite anxiety symptoms and features in their child. Signs of inattention and heightened activity levels were indicated by 52% of parents for children included in our study, although no diagnosis of Attention Deficit Hyperactivity Disorder (ADHD) had been indicated for their child at the time of our study.

Table 4.1 Summary of participants' demographics (n=21)

Demographic characteristic	Frequency (Percentage)
Age Range	
4-5 years	8 (38%)
5-6 years	8 (38%)
6-7 years	2 (10%)
7-8 years 11 months	3 (14%)
Gender	
Male	12 (57%)
Female	9 (43%)

4.2.1 Short Sensory Profiles of Participants

Figure 4.1 illustrates the frequencies of sensory processing difficulties present in the sample (n=21), according to category and total scores on the SSP. The inclusion criteria required the participants to score below -1.5 SD on one or more of the subtests on the SSP. Of the participants in the study sample, 71.4% obtained significant "definite differences" for total test scores on the SSP. This indicated marked dysfunction in sensory processing overall. The remaining participants fell into the borderline ("probable difference") range (23.8%) for total SSP scores, except for one participant whose overall sensory processing score was within the normal ('"typical performance") range on the SSP. However, her tactile sensitivity and touch processing difficulties were within the "probable difference" and "definite difference" range on the SSP and SP, respectively. Furthermore, she fell within the "sensitivity to stimuli" and "sensation avoiding" quadrants on the SP, with more "probable differences" indicated for both.

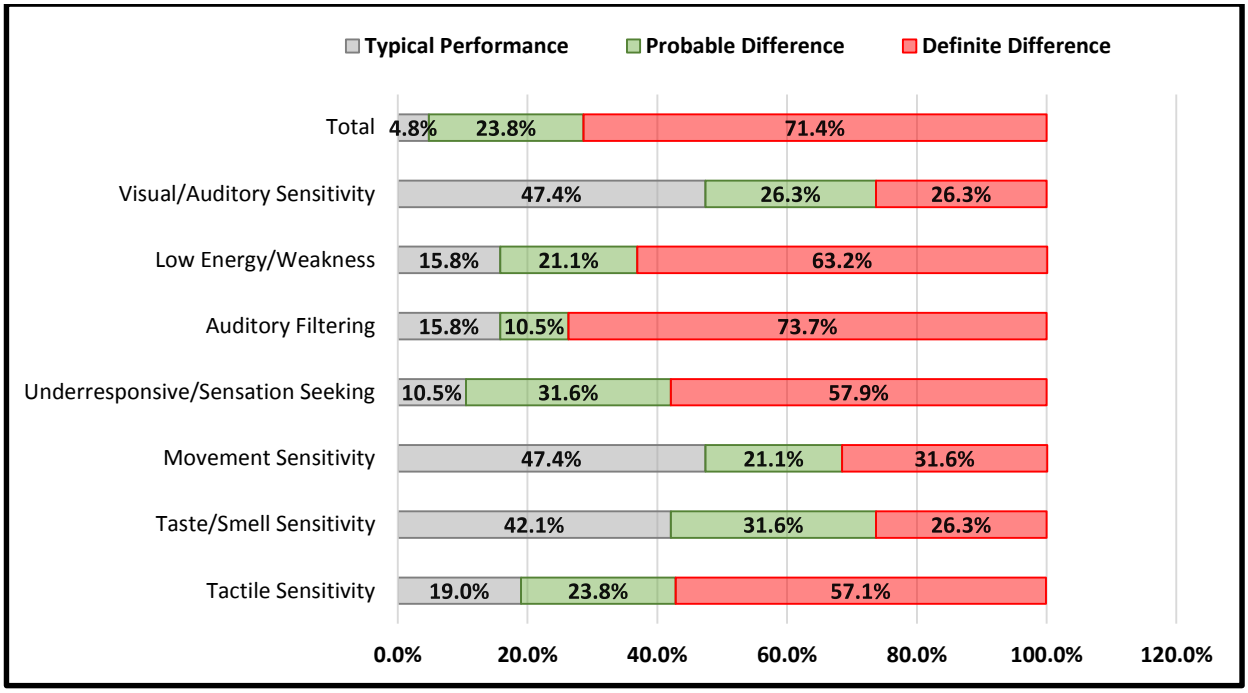

Figure 4.1 Frequency of overall sensory processing difficulties from the SSP (n=21)

Typical Processing: score between ± 1 SD for typical sensory processing abilities
Probable Difference: score between 1 and 2 SD above or below the mean
Definite Difference: score below 2 SD above or below the mean mark for sensory processing problems.

The majority of participants' scores for tactile sensitivity fell within the "definite" (57.1%) to "probable" (23.8%) difference range. Nineteen percent of participants' scores for tactile sensitivity were normal ('typical range" between ± 1 SD). These four participants obtained "probable difference" (4.76%) to "definite difference" (14.28%) total test scores. They also had scores of ≥-1.5 standard deviations (SD) below normative means for total z scores on more than one other subtest, one of which included underresponsivity/sensation seeking for all four participants. Thus, these participants were included in the study sample.

Overall, auditory filtering (indicating either hyporesponsiveness or obliviousness to sound, or hyperresponsiveness or oversensitivity to sound) and low energy/weakness were the items on the SSP for which the highest percentages of "definite differences" were found among the participants. "Definite differences" in their ability to filter auditory input was found among 73.7% of participants and 63.2% of the sample had "definite differences" in the low energy/weakness category. On the whole, almost half the sample of participants (47.4%) fell within the "typical performance" range for both visual/auditory sensitivity and movement sensitivity. A

higher percentage of the participants (42.1%) also fell into the “typical” range for taste/smell sensitivity.

Based on the quadrant classification (Dunn, 1999) (Figure 3.2) from the Sensory Profile, most participants displayed either sensitivity to stimuli (73%) or low registration (68%). Nearly two thirds of the participants were seen to be sensation avoiding (with low thresholds), while 42% were sensory seeking (with high thresholds).

4.3 COMPARISON PRE- AND POST-INTERVENTION

The data from all 21 participants was considered in the analysis of behaviour. However, the changes in salivary cortisol levels of one participant could not be measured due to exponentially high cortisol levels both pre- and post-test (i.e., cortisol concentrations in his saliva were too high to fall within the normally distributed curve of mean values used by the Salimetrics ELISA kit). Ultimately, this participant could not be included in the statistical tests run on cortisol data. The behaviour of this participant was, however, accounted for in order to explain this atypical finding.

4.3.1 Change in Negative Behaviours Present

The behavioural data was presented as means and standard deviations of behaviours observed during the measurement period prior to the intervention and post intervention (i.e., 15-minutes pre-test and 15-minutes post-test). The specific behavioural items analysed (pre-test post-test) that showed significant results for a reduction in negative behaviour, or those where more than four behaviours were observed in either the pre-test or post-test total observations, were considered.

From the 32-item Behaviour Assessment Scale of negative behaviours, six items (including items 4, 21, 23, 24, 26 and 28) were removed in the statistical analysis because none of these behaviours was observed (i.e., no trend could be established). Analysis of the categories for each group of item was then considered. Effect sizes were also provided and are discussed.

4.3.1.1 Pre- and Post-Test Comparison of Specific Behavioural Items

Behaviours that yielded statistically significant differences pre- and post-test or where more than four behaviours were scored in the pre-test or post-test observations, were analysed (Table 4.2).

Table 4.2 Pre- and post-test comparison of total negative behaviours present on each Item

Behaviour Item		No. of Behaviours Observed #	Pre-test Post-test Difference$	Pre-test Mean (SD)	Post-test Mean (SD)	p-value*	Effect Size d
1 Concentration, Attention, and Readiness for task							
2	Looks away from task to notice all actions in the environment.	352	-110	11.00 (5.57)	6.05 (4.16)	0.00**	1.18
6	Low arousal, hypo-responsiveness, and decreased postural adjustments to task.	22	-2	4.00 (2.00)	3.33 (3.21)	0.11	0.34
7	Poor maintenance of seated posture.	210	-48	7.16 (4.46)	5.17 (4.20)	0.00**	1.70
8	Fails to notice opportunities for engagement.	13	-9	4.00 (0.00)	2.00 (0.00)	-	-
2 Behaviour in Group							
11	Disrupts group, disturbs others.	9	-5	1.40 (0.55)	1.00 (0.00)	1.00	0.73
12	Demands to be in the spotlight, seeks attention.	13	-11	5.50 (3.54)	1.00 (0.00)	0.29	1.27
3 Perseverance and Task Completion							
14	Gives up easily and fails to complete the task.	9	-9	1.80 (0.84)	0.00 (0.00)	0.11	2.14
15	Showing avoidance of tasks presented.	24	-22	5.75 (6.39)	1.00 (0.00)	0.20	0.74
16	Transitioning between tasks without completing given task.	16	-2	1.50 (0.84)	2.33 (2.31)	0.35	0.98
4 Organisational Ability							
17	Disorganised on self, in his/her work, work lacks planning.	49	-11	3.33 (2.39)	2.37 (2.38)	0.05	0.40
18	Can't get down to his/her work.	10	-8	1.50 (0.87)	1.00 (0.00)	0.42	0.57
20	Requires step-by-step instructions.	6	-3	2.00 (1.73)	3.00 (0.00)	0.18	0.58
22	Requires mediation in the task	36	-14	2.27 (1.48)	1.38 (0.74)	0.30	1.20
5 Ability to Cope with New Situation							
25	Appears anxious, lacks confidence and withdraws.	13	-11	2.40 (1.14)	1.00 (0.00)	0.33	1.23
6 Social Interaction							
7 Responsibility, Initiative							
30	Unable to initiate activities.	18	-12	1.67 (1.00)	1.00 (0.00)	0.35	0.67
31	Unable to carry task out independently.	6	-4	3.00 (0.00)	2.00 (0.00)	0.18	-
32	Seeks reassurance & affirmation during tasks.	98	-26	4.13 (3.09)	4.00 (4.15)	0.00**	0.04

* p-value significant at p<.05,
**p value significant at p<.01
Pre-test and post-test total observations for all items combined
$ Negative indicating a reduction in behaviours from pre-test to post-test

Items 1,3,5,9,10,13,19,27 and 29 were, therefore, not considered in this aspect of the analysis as the behaviours in these items were observed less than four times in the pre-test or post-test.

A statistically significant reduction in negative behaviours present was observed on items 2, 7 and 32. These three items were those with the highest number of observations and resulted in the greatest reduction of negative behaviours with the greatest negative difference between pre-test and post-test mean values.

The greatest pre- and post-test difference was found to be -110 for item 2, “looks away from task to notice all actions in the environment at things he/she hears or sees”. The participants were all seen to look away from the task numerous times at sensory stimuli (i.e., things he/she hears or sees) around the room prior to the intervention. Participants’ ability to filter out external sensory input (auditory/visual) significantly improved in the post-test phase (p=0.00).

Likewise, a statistically significant difference was seen after the intervention for item 7, “poor maintenance of a seated posture”, where participants used less exaggerated postural background movements (propping self up on arms for stability, leaning on table, sitting on edge of chair, fixating by wrapping legs around chair) and made more appropriate postural adjustments to tasks (less slouching or shifting of whole body, more centered to task to cross body midline more freely).

Generally, participants were seen to “seek reassurance and affirmation” (item 32) significantly less during tasks even though the new tasks were unfamiliar to them in the post-test phase, differing from those they were exposed to in the pre-test. These items (items 2, 7 and 32) were the items on which the highest number of observed behaviours was rated. Therefore, significance was only found for items with a high number of observations. Consequently, effect sizes were considered for items with four or more observations, as large effect sizes could not be discounted, even though the change was only seen in fewer children than those items where significance was found.

Participants’ perseverance and task completion showed noticeable improvement, on item 14, “gives up easily and fails to complete the task”, as indicated by a large effect size (2.14) found for this item. This item showed the largest effect size compared to all other items analysed from the scale. Although fewer observations

were recorded on item 14, the Wilbarger DTPT appeared to have a greater effect on changing this specific behaviour in the five children who displayed observations in the pre-test, where no observations were recorded on this item in the post-test. Four out of the five participants who displayed this specific behaviour were among the participants who showed the greatest change in behaviour overall across the sample (n=5) after receiving the DTPT, all of whom had “probable” to “definite differences” in tactile sensitivity on the SSP.

The following items all showed clinically significant differences with large effect sizes: item 12, “demands to be in the spotlight, seeks attention”; item 16, “transitioning between tasks without completing given task”; item 22, “requires mediation in the task”, and item 25, “appears anxious, lacks confidence and withdraws”. Although change on these items was only seen in a few children with less observations recorded compared to significant items, the large effect sizes indicate that the change in these behaviours moved the participants into a more normal range of behaviour.

Consistent behaviour was seen in all participants who were scored on item 5, “has difficulty paying attention, distracted internally”, showing no change positively or negatively following implementation of the Wilbarger DTPT. An increase in negative behaviour was observed during the post-test phase for item 13, “easily frustrated when attempting task”. A regression in behaviour, noted as an increase in the frequency of negative behaviour, was also seen for item 1, “easily distracted by own thoughts, daydreams”, even though only one participant displayed internal distractibility rated on this item. However, these items (items 5, 13 and 1) where consistent or regressive behaviour was seen, were removed from the analysis due to the low number of observations made for these behaviours (i.e., less than four behaviours overall).

In summary, there was a reduction in negative behaviours on all 17 items included in the analysis (Table 4.2). A mean decrease in behaviours overall on these 17 items was found to be -16.88, with a SD of 26.48. A total of only two participants (9.53%) in the entire sample (n=21) displayed an increase in negative behaviours after the intervention was administered.

4.3.1.2 Reduction in Mean Values of Behavioural Categories Overall Pre- and Post-Test

Given the variation in the individual items further analysis was, therefore, carried out on the eight behavioural categories in the scale. This allowed the change in behaviour overall to be assessed within each of these subsections. The effect of the intervention is highlighted in Table 4.3 comparing the pre- and post- intervention results for each category of behaviour from the scale. A visual summary of this comparison is provided in Figure 4.2, which illustrated a reduction in mean values from the pre-test to the post-test for all behavioural categories.

Table 4.3 Pre- and post-test comparison of total negative behaviours present in each behavioural category (n=21)

Behaviour Category	No. of Behaviours Observed #	Overall Pre-test Post-test Difference $	Pre-test Mean (SD)	Post-test Mean (SD)	p-value	Effect Size
Category 1 Concentration, attention & readiness for task	603	-172	17.95 (7.80)	10.62 (7.34)	0.00**	0.99
Category 2 Behaviour in group	35	-23	1.29 (1.95)	0.33 (0.66)	0.00**	1.45
Category 3 Perseverance and task completion	51	-31	1.95 (3.61)	0.48 (1.25)	0.03*	1.18
Category 4 Organisational ability	107	-39	3.48 (3.87)	1.61 (2.50)	0.27	0.75
Category 5 Ability to cope with new situation	14	-12	0.62 (1.32)	0.05 (0.22)	0.07	2.59
Category 6 Social interaction	3	-1	2.00 (0.00)	1.00 (0.00)	1.00	–
Category 7 Responsibility, initiative	124	-42	3.95 (3.32)	1.90 (3.33)	0.10	0.62

* p-value significant at p<.05,
**p value significant at p<.01
Pre-test and post-test total observations for all items combined
$ Negative indicating a reduction in behaviours from pre-test to post-test

When looking at these categories, the greatest change in behaviour was seen in category 1, “concentration, attention and readiness for task”. (Figure 4.2) A significant statistical (p=0.00) reduction in behaviour was found for this category

overall, with two of the eight items (items 2 and 7) within this category both showing significant reductions in negative behaviours post-intervention. All except two participants (9.52%) showed marked improvements in behaviours associated with concentration, attention and readiness for tasks. The results may have been influenced by the high number of observations in this category, which had an overall effect size of 0.99 for the reduction seen in negative behaviours associated with this category.

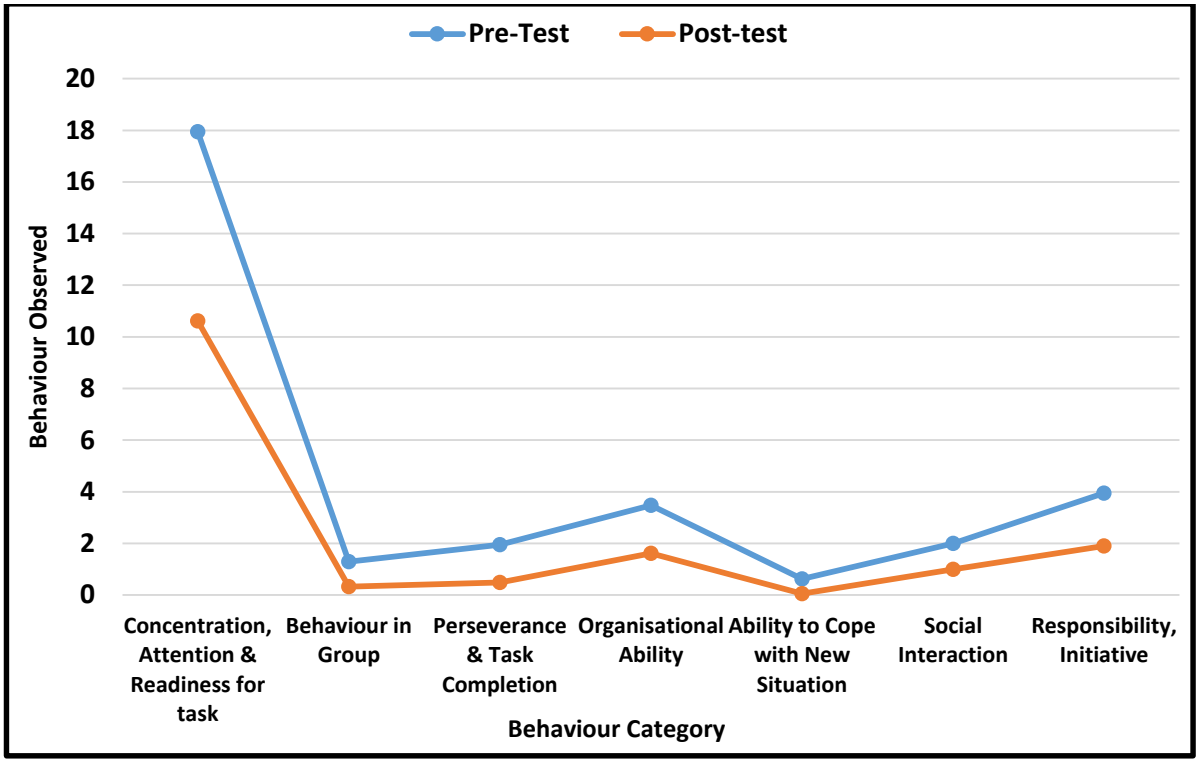

Figure 4.2 Pre- and post-test means of total negative observed behaviours compared by category (n=21)

When examining category 2, “behaviour in the group”, all ten of the participants who were rated on the items in this category improved in their post-test scores on two items considered in the analysis - item 11, “disrupts group, disturbs others”, and item 12, “demands to be in the spotlight, seeks attention”. In total, there was a significant statistical (p=0.00) decrease in negative in-group behaviour, as well as a large effect size of 1.4.

In category 3, “perseverance and task completion”, participants’ performance improved significantly statistically (p=0.03), mainly related to considerably lower post-test scores for item 14, “gives up easily and fails to complete the task”, and item 15, “showing avoidance of tasks presented”. Interestingly, one of the two items in the scale where a small increase in post-test scores of two observations was found, included item 13, “easily frustrated when attempting tasks”. However, despite similar levels of frustration being displayed in the pre- and post-test, participants did not seem to avoid the tasks presented as much in the post-test, with a reduction to only one observation from 23 for item 15. This contributed to a large effect size between pre- and post-test scores of over 1.1 for this category.

No observations were made for item 21, “impulsive, works too fast” in category 4, “organisational ability”, yet negative behaviours reduced overall on the other items in this category (although not significantly), with only five participants regressing in this area. Thus, 76% of participants showed improvement in their organisation and planning ability during the post-test phase, getting down to their work and completing tasks with less step-by-step instructions and mediation required. A medium effect size was therefore calculated for this category.

In category 5, “ability to cope with new situation”, no observations were rated on three of the five items that included item 23, “refuses to attempt new tasks, persists only with easy tasks”, item 24, “becomes overexcited, lacks self-control”, and item 26, “takes control of the situation and those around him/her”. Therefore, mean values for the change in behaviour seen in this category overall were low, but a decrease in negative behaviours on the remaining items was still found, although not significant (p=0.07). The effect size for this category was the largest recorded, due to a reduction of all but one negative behaviour in the post-test. This was based on a total of 13 observations of negative behaviours in the pre-test.

As depicted in Table 4.3, no significant difference was found between total pre-test and post-test scores for category 6, “social interaction”, and category 7, “responsibility and initiative”. When considering the items in these categories, inconsistencies appeared to be noted throughout the sample within both categories. While one child improved in their aggressive behaviour (item 29, “is aggressive or rough with others”), another child became seemingly more rough during the post-

test activities, although only two participants were rated on this item. An effect size could not be calculated for category 6 due to the small number of behaviours rated on the items within this category. Therefore, this category should be removed from the scale in future, given that no statistical significance was found when included.

In terms of category 7, "responsibility and initiative" shown", a high frequency of observations was made. Item 32, "seeks reassurance and affirmation during tasks", was the most frequently rated item and across the 15 participants who displayed this behaviour, ten showed improvement, while three regressed and two behaved consistently, in needing reassurance and affirmation. The effect size for the category was therefore medium.

The strength of the effect sizes and the statistical significance found for categories 1, 2 and 3 indicates that the greatest change was seen within these areas of behaviour on the scale overall. The large effect size seen for category 5, "ability to cope with new situation", indicates that the greatest reduction of negative behaviours was found for this category post-test, although the number of observations in the category were relatively small. Therefore, the improvement in behaviour within these categories further supports the inclusion of these categories within the Daily Behaviour Assessment Scale for future research.

4.3.2 Change in Self-Regulatory Behaviours Present

The change in self-regulatory behaviours was added to the end of the Daily Behaviour Assessment Scale and these were considered separately. Although no significant change was found for all items, a trend developed that is explained below. The items included in this category cannot necessarily be considered as negative behaviours, thus were considered within a separate analysis. Participants' behaviour on these items was described in terms of an increase or decrease in their use of sensory input (i.e., the level/amount of sensory input needed to self-regulate). Changes in the category overall were also clarified and effect sizes were reported.

4.3.2.1 Pre- and Post-Test Comparison of Self-Regulatory Behaviour

Table 4.4 depicts the results for the self-regulation category overall and the three items within this category, showing the changes between pre- and post-test scores. No statistical significance was found for any of the individual items.

The category of self-regulation had the second highest number of behaviours rated on the observed items. Therefore, a high frequency of self-regulatory behaviours was observed (297 in total during both phases of the Activity protocol). The mean difference (0.05) between the number of pre- and post-test observations shows an overall decrease in the post-test, although this difference is small. This means that altogether the participants' use of sensory input to regulate their behaviour decreased once they had received the intervention.

Table 4.4 Items showing a significant difference in self-regulatory behaviours present (n=21)

Behaviour Item		No. of Behaviours Observed #	Overall Pre-test Post-test Difference $	Pre-test Mean (SD)	Post-test Mean (SD)	p-value	Effect Size
Category 8 Self-Regulation		297	-1	7.10 (4.88)	7.05 (4.75)	0.65	0.01
33	Uses movement input (fidgeting, rocking on chair, shifting body, swaying).	85	5	4.02 (2.70)	4.09 (3.78)	0.87	0.03
34	Uses proprioceptive/tactile/oral input (stamping feet, sucking on objects/fingers, pulling, touching or rubbing self/objects)	198	-18	5.68 (3.68)	5.00 (3.65)	0.15	0.19
35	Uses auditory input (whistling, making noises, singing)	13	12	1.00	2.60 (1.67)	–	2.39

* p-value significant at p<.05,
**p value significant at p<.01
Pre-test and post-test total observations for all items combined
$ Negative indicating a reduction in behaviours from pre-test to post-test

An increased trend in the number of observations present on item 33 and item 35 was found. Conversely, participants used less proprioceptive, tactile and/or oral input (stamping feet, sucking on objects/fingers, pulling, touching or rubbing self/objects) overall to achieve self-regulated behaviour observed on item 34 in the post-test. When comparing their use of somatosensory and oral input in the pre-test, participants required far greater amounts to achieve self-regulation prior to receiving the Wilbarger DTPT (with a difference of 18 less observations made in the post-test across the sample).

Of the 14 participants who were rated on item 33, “uses movement input”, 38% used a greater amount of movement input (i.e., fidgeting, rocking on chair, shifting body, swaying) in the post-test phase. Of the remaining participants, 29% used less movement input to self-regulate in the post-test and 33% did not use movement input in the pre- or post-test to regulate their sensory system. Overall, the use of movement to self-regulate showed an increase across the sample, though this was not significant (p=0.87).

Item 34, “uses proprioceptive/tactile/oral input” showed the largest change, as indicated by the difference between pre-test (5.68) and post-test (5.00) mean values, although the difference was not statistically significant (p=0.15). All 21 participants displayed observations rated on this item, with 57% using less somatosensory/oral input. Twenty-four percent used more of this type of input and 19% used the same amount of this input in the post-test phase.

Effect sizes for the observed changes were small except for item 35 where a few observations were recorded among only five participants, and therefore, this result cannot be generalised to the whole sample. Specifically, four of the five participants rated on item 35, “used auditory input (whistling, making noises, singing)”, only in the post-test (i.e., behaviour increased). The other participant used it consistently throughout, falling among the rest of the sample who also showed no change, as indicated in Figure 4.3, due to them not using auditory input.

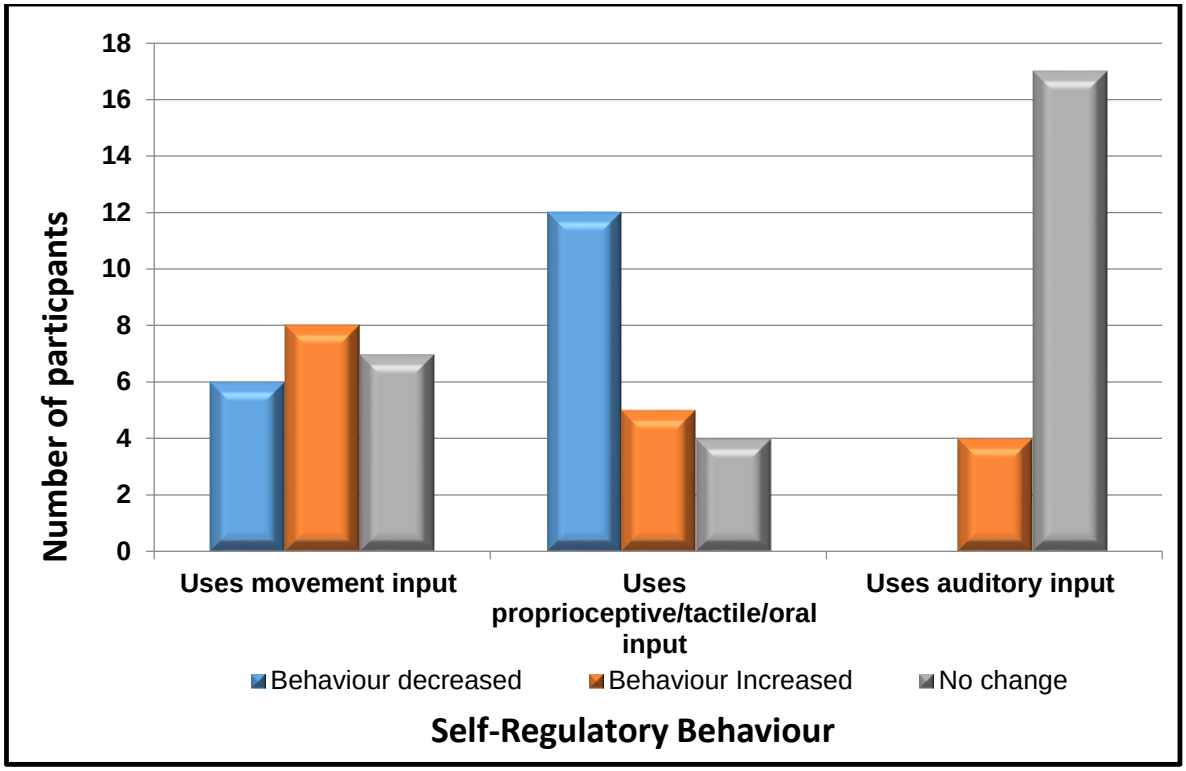

Figure 4.3 Changes in self-regulatory behaviour across the sample (n=21), comparing each item.

The changes in participants' self-regulation on each item are illustrated in Figure 4.3. A large decrease in participants' use of proprioception/tactile/oral sensory input (with an effect size, 0.19) in the post-test is shown in the graph. However, participants' use of movement and auditory input increased overall (with effect sizes of -0.03 and -2.39, correspondingly).

4.3.3 Change in Salivary Cortisol Levels

The researcher from the physiology department, who assisted in conducting the analysis, indicated that the quantity of saliva collected for each participant was sufficient so that concentrations of cortisol could be measured for all participants. Table 4.5 below illustrates the change in salivary cortisol levels across the sample with an overall difference between pre- and post-test mean values of -0.02 (the minus indicating a decrease). Cortisol was seen to decrease on the whole in the sample (n=20), although the difference was not statistically significant, where p=0.14.

Cortisol measures from one participant were excluded from the data analysis. His levels of salivary cortisol for both the pre- and post-test were higher than the control ranges set by Salimetrics (Salimetrics, 2012). In other words, his measures were off the curve of normally distributed values of cortisol concentrations used by the Salimetrics kit and, therefore, could not be used. This participant's caregiver described him as having "chronic anxiety in every aspect of life", as well as "extreme fear of failure". This participant has since received a psychiatric diagnosis of Generalised Anxiety Disorder following completion of the study, which may have confounded these results and explains this finding.

Table 4.5 Pre- and post-test comparison of salivary cortisol levels (n=20)

		Valid Sample				
Salimetrics Expected range*** Children 2,5 – 11 years		397	Afternoon Mean 0.13 (0.05 – 0.21)			
		Valid Sample	**Pre-test Mean (SD)**	**Post-test Mean (SD)**	**p-value***	**Effect Size**
Cortisol	Total sample	n=20	0.11 (0.04)	0.09 (0.03)	0.14	0.67
	Group 1: Decrease in cortisol	n=12	0.12 (0.04)	0.07 (0.02)	0.00**	2.5
	Group 2: Increase in cortisol	n=5	0.08 (0.02)	0.12 (0.02)	0.04*	2.0
	Group 3: No change in cortisol	n=3	0.09 (0.04)	No change	-	-

* p-value significant at p<.05
**p value significant at p<.01
***(Salimetrics, 2014)

The changes in cortisol fell into three distinct groups - a group of twelve participants whose cortisol levels decreased, a group of five participants where there was an increase in cortisol levels, and a group where there was no change in the cortisol levels of three participants. Analysis was based on these groups rather than the total

group, as the decrease and increase in cortisol affected the mean change for the total group.

In the first group, the mean concentrations of cortisol in the saliva of 12 participants (60%) were higher at baseline on the normally distributed curve of mean values of cortisol in saliva provided by Salimetrics (Salimetrics, 2012). Given that the study was conducted in the early afternoon when salivary cortisol levels are most stable, the peak in cortisol production following a circadian rhythm (i.e., highest values found in the morning) was accounted for. After the Wilbarger protocol-based technique was applied, a decrease in these participants' cortisol to within a more normal range of expected levels was found. This decrease was significant for the change between pre-test and post-test levels, at p=0.00. Of the 12 participants whose cortisol levels decreased after receiving the intervention, seven had more "probable" (58.33%) and five had more "definite" (41.66%) differences in sensory sensitivity on the SP. Furthermore, their total test scores on the SSP were within the "probable difference" (41.66%) or "definite difference" (58.33%) ranges, indicating marked sensory processing difficulties.

In group 2, salivary cortisol levels increased. The five participants' SSP scores recorded at the time of the study indicated "probable" to "definite" differences in underresponsiveness. Interestingly, the pre-test levels of these participants were among the lowest levels recorded in the sample at baseline, prior to the intervention (along with three other participants in group 3 whose cortisol levels were as low at baseline but remained the same in the post-test). Therefore, it appears that the Wilbarger DTPT increased the cortisol levels of these participants up to more normal levels. The increased change in cortisol found in these participants was significant, at p= 0.04.

In group 3, consistent levels were found for three participants in their pre-test and post-test measures, meaning that no change was detected and salivary cortisol levels stayed the same before and after the intervention. All of these participants showed more "definite differences" in low registration on the SP and presented with "probable" (two participants) to "definite" (one participant) differences in underresponsivity on the SSP. As with the participants who showed an increase in cortisol, these participants appeared also to have sensory underresponsive profiles.

The average baseline measure for the group of participants whose post-test cortisol levels decreased was 0.12, and for the participants whose post-test cortisol levels showed an increase or remained the same, their average baseline measure was 0.08. When comparing the average baseline measures of salivary cortisol concentrations between both groups, they were significantly different, where p=0.05. This shows that, for the participants with sensory sensitivity, their baseline cortisol levels were higher, whereas for participants with underresponsive profiles their baseline cortisol levels were lower, and these decreased (for the sensory sensitive participants) and increased (for the underresponsive participants), accordingly.

When considering the effect size (0.67) for change in cortisol levels for the total group, it was moderate since some levels went up and some went down. When the increase and decrease in cortisol levels were analysed alone, the effect size was large, indicating that trends for an increase or decrease must be considered separately depending on the cortisol levels found at baseline.

4.3.4 Reduction in Negative Behaviours and Changes in Salivary Cortisol Levels Linked to Tactile Defensiveness

According to the SSP, 19% of the sample (four participants) presented with “definite differences” in tactile sensitivity and a further one participant was identified on the SP as having a “definite difference” score in touch processing (i.e., tactile defensiveness). These participants, with marked tactile processing deficits, displayed the greatest change after the intervention in terms of the highest reduction in negative behaviours found from the pre-test to the post-test. The decrease in negative behaviours ranged from -23 to -35, with an overall mean decrease in these participants’ scores of -28.2.

Table 4.6 depicts the difference between mean scores overall (pre- and post-test) for behaviour and cortisol data, for these five participants with “definite differences” in tactile sensitivity and touch processing compared to the rest of the sample of 16 participants with “probable” or no differences in tactile sensitivity.

Table 4.6 Significant decrease in the behaviour of five participants compared to the rest of the sample (n=21)

Variable		Valid Sample	Mean Difference (SD) #	p-value*
Difference in Behaviour	No or probable differences in tactile sensitivity and touch processing	n=16	-9.56 (8.52)	0.00**
	Definite differences in tactile sensitivity and touch processing	n=5	-28.20 (5.81)	
Difference in Cortisol	No or probable differences in tactile sensitivity and touch processing	n=16	-0.01 (0.05)	0.18
	Definite differences in tactile sensitivity and touch processing	n=5	-0.04 (0.06)	

* p-value significant at p<.05,
**p value significant at p<.01
Negative indicating a reduction in behaviour/cortisol overall from pre-test to post-test

The results from the Mann Whitney U test reveal significance for the reduction in negative behaviour in participants with “definite differences” in tactile sensitivity and touch processing compared to the rest of the sample (p=0.00). This means that there was a significant reduction in negative behaviour in these five participants compared to the reduction seen in participants with “probable” or no tactile sensitivity and touch processing difficulties. In terms of the largest reduction recorded in negative behaviour overall, participants with definite tactile defensiveness (as indicated by their sensory profiling), benefited the most from the Wilbarger DTPT.

A decrease in salivary cortisol levels was found in four out of the five participants with tactile defensiveness. The post-test cortisol levels in their saliva were lower after the Wilbarger DTPT, compared to their baseline measures. The decrease found between pre- and post-test levels ranged from -0.02 to -0.12 from baseline measures. The final participant’s salivary cortisol levels increased by 0.05 in the post-test after the intervention was administered.

4.4 THE ASSOCIATION BETWEEN NEGATIVE BEHAVIOURS AND SALIVARY CORTISOL LEVELS

4.4.1 Association Between Negative Behaviours and Salivary Cortisol

The overall effect of the intervention on negative behaviours and sympathetic arousal measured by salivary cortisol levels was determined using a correlation between the difference in behaviour and the difference in salivary cortisol levels overall. The results generated showed a correlation of r=0.22 (with significance set as p<.05), revealing a weak correlation between the change in these two dependent variables. This indicates that, although significant changes in behaviours and cortisol levels were found, the changes in salivary cortisol did not correlate strongly with the changes in behaviour.

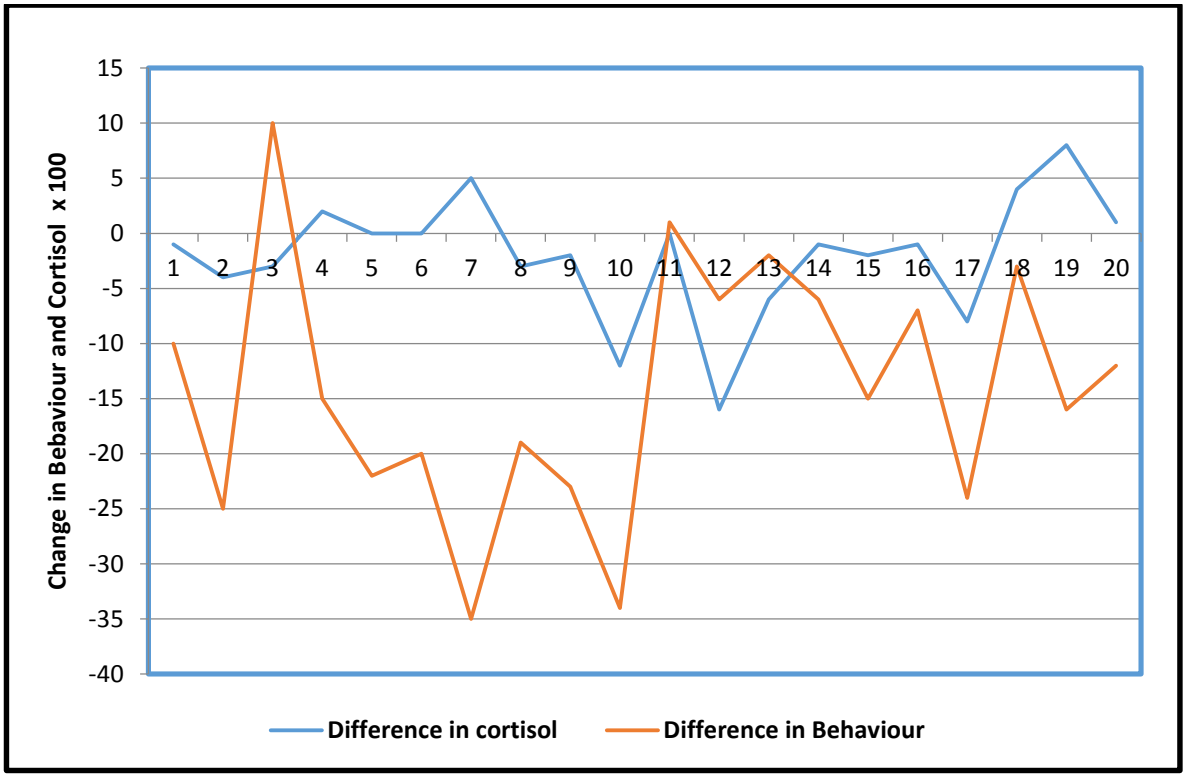

Figure 4.4 The change in behaviour compared to the change in cortisol (X100) across the sample (n=21)

Figure 4.4 represents the change in behaviour and cortisol level scores that have been modified by 100 to make the scores comparable. The difference in behaviour and cortisol is illustrated for each participant, showing the participants whose

behaviour and cortisol changed the most (i.e., more variance in the height of the curve, either increasing or decreasing). Although the levels of cortisol in the sample went up and down, this was not equivalent to the change seen in behaviour, hence, a weak correlation was found between the two variables.

When the change for the groups where the cortisol levels increased or decreased was correlated with the change in behaviour, the correlations remained weak at r=0.22. This indicated that the association between these variables is not strong and that other variables such as the type of SMD appear to play a role.

There was no significant correlation between self-regulation and salivary cortisol changes (r= 0.32) although both self-regulation and salivary cortisol levels decreased on the whole.

4.4.2 Correlation of Behavioural Categories

When correlating the changes in behaviour from each behavioural category with changes in salivary cortisol levels, a moderate correlation was found (p=0.41) with changes in category 7, “responsibility, initiative”. In all other categories, low correlations were found between behaviour and cortisol changes.

When correlating the changes within each category of negative behaviours, category 7, “responsibility, initiative”, correlated with category 3, “perseverance and task completion” (r=0.64). Category 2, “behaviour in group”, correlated moderately with category 4, “organisational ability” (r=0.53). These correlations show that changes in the one category correlated with the changes in the other category although these were only moderate correlations.

4.5 CONCLUSION

These findings provide evidence that a once-off application of the Wilbarger DTPT yielded significant results for changing behaviour in the post-test phase. Specifically, a decrease in negative behaviour was seen in general with a reduction between pre- and post-test means (from total scores) being significant in three out of the seven categories rated. Of these three categories, a large effect size was found for the change in negative behaviours observed within category 1, “concentration, attention and readiness for task”, category 2, “behaviour in group”, and category 3,

“perseverance and task completion”. Therefore, the null hypothesis that the Wilbarger DTPT does not influence the negative behaviours associated with sensory modulation dysfunction is rejected for these categories of behaviour but accepted for the remaining categories where no statistically significant changes overall were found. However, a large effect size was found for category 5, indicating clinical change that needs to be investigated further.

The amount of sensory input used to self-regulate varied across participants but an overall decrease (although not significant) in participants’ use of proprioceptive/tactile/oral input was seen. Participants required less of this sensory input in order to self-regulate and yet they maintained more optimal arousal levels, evidenced by the positive change in behaviour seen in the group as a whole. The reverse pattern of this was found in participants’ need for movement and auditory input in the post-test, which increased overall (although not significantly). An improvement was seen in 19 of the 21 participants’ ability to maintain an optimal range of performance, displaying less negative behaviours following the intervention. However, due to no significance found overall, the null hypothesis that the Wilbarger DTPT does not change self-regulation is accepted.

The change between pre- and post-test mean values for salivary cortisol levels of participants was not significant when examining this across the total sample. However, trends were established when the groups of participants whose cortisol levels increased, decreased or stayed the same, were considered. In the participants who were underresponsive to sensory stimuli, their levels of cortisol increased, while cortisol levels dropped in participants who were overresponsive to sensation. The overresponsive participants showed more marked changes in negative behaviour as reflected by higher differences between their pre- and post-test behaviour scores, performing better in the post-test phase of the study (showing less negative behaviour). The results of the change in these five participants’ behaviour, when compared to the remainder of the group, showed significant differences.

There appeared to be a trend that developed for participants whose salivary cortisol levels stayed the same or increased. All had “probable” to “definite difference” in sensory underresponsivity and low registration, with significantly lower baseline

cortisol levels. These participants had more of an underresponsive (SUR) sensory profile and, therefore, mostly showed increases in their cortisol levels or no change after the intervention. The participants whose behaviour improved the most post-intervention, all had sensory overresponsiveness (SOR) with tactile defensiveness.

Four of the five participants in the latter group experienced a reduction in their salivary cortisol levels post-intervention. The participant who differed from this pattern (i.e., the change in salivary cortisol) also differed in terms of his sensory profiling, as he presented with “definite differences” in low registration (in addition to sensory sensitivity). This is thought to have influenced the increase seen in his cortisol levels, given that this finding was present among the rest of the group.

This means that after administration of the Wilbarger DTPT, participants’ salivary cortisol levels changed in the direction of modulation expected. This finding did show statistical significance, with a large effect size when the group with an increase and decrease in cortisol levels was considered separately. The null hypothesis that the Wilbarger DTPT does not influence cortisol levels or sympathetic arousal in children with sensory modulation disorders was therefore rejected.

The overall change in behaviour could not be correlated with the change in salivary cortisol levels, as the correlation was weak ($p=0.02$). The intervention was only administered once-off in this study and not as the Wilbarger protocol is intended to be prescribed. This did, however, mean that the changes which we observed in behaviour, self-regulation, and salivary cortisol were attributable to the procedure itself and not to changes in the participants’ abilities caused by uncontrolled variables over time.

CHAPTER 5: DISCUSSION

5.1 INTRODUCTION

Chapter five encompasses the discussion of the patterns of sensory processing across the sample population. The effectiveness of the Wilbarger DTPT in changing participants' behaviour, self-regulation, and salivary cortisol levels has then been reviewed. The changes are related back to the subtypes of SMD, which are compared. Thereafter, the association between behaviour and salivary cortisol changes are considered. Possible extraneous variables that may have influenced the results are highlighted. In conclusion, the limitations of this study are presented.

5.2 DEMOGRAPHIC DATA AND SENSORY PROFILING OF PARTICIPANTS

When analysing the demographic information of the study sample, participants' gender, stage of development, sensory processing subtype, and pattern of self-regulation related to their sensory profiling, was examined. The terms sensory defensiveness and sensory overresponsivness are used interchangably when discussing this subtype of SMD in the literature, while tactile defensiveness describes sensory overresponsivity when it occurs only in one sensory system (i.e., the tactile system). Although children with neurotypical development were included in the study, attention problems and features of anxiety present among participants were considered. An explanation for the heterogeneity of the study sample has been provided.

5.2.1 Gender and Developmental Differences

Among the study sample, more than half (57%) were male, while female participants formed the minority (43%). This is in line with current research evidence to date that has shown boys to have more sensory processing impairments than girls (Stalker and Reebye, 2007). Conversely, more girls display greater signs of tactile defensiveness than boys (Goldsmith et al., 2006, Bröring et al., 2008). However, there were equal numbers of male and female participants in the study sample whose scores for tactile sensitivity showed "definite differences".

Literature specific to developmental trajectories explaining the increase or decrease in the prevalence of SMD with age is essentially limited.

The participants in this research ranged in age from four years to eight years and eleven months. Clinically, the target population for occupational therapists treating SMD, is predominantly the paediatric population. A reason for this may be that with age, one becomes increasingly more able to adapt one's lifestyle, relationships and careers to meet one's sensory preferences and needs, as one learns to develop coping strategies. Recent literature states that most children learn to adjust their sensory needs and behaviour by the age of six. However, for children with SMD it is only by the age of eight when their social skills increase that their behavioural symptoms decrease (Stalker and Reebye, 2007). Therefore, an assumption can be made for children with SMD that their symptoms become less obvious as they are more cognitively able to self-regulate themselves.

Based on this premise, it would be expected that older participants in this study would display less overt negative behaviour. From the results, it was evident that no observations were made for older participants (age range 7 – 8 years 11 months) on items describing negative behaviours of social interaction. This may have impacted the overall result for this category as no change was found for observable behaviours of social interaction across the total sample. A limited number of behaviours was rated for category 6 and of those rated, observations were made either in the pre-test or post-test phase with no difference found between scores. Due to the small sample size of this research and limited available literature describing developmental trajectories of SMD, this finding cannot be generalised with confidence.

5.2.2 Sensory Processing Patterns

Results on the SSP showed 71.4% of participants (Figure 4.1) had significant "definite differences" for their overall processing of sensory input with just over half having "definite differences" in tactile sensory sensitivity or sensory under-responsiveness.

A limitation of the SSP is that the underresponsive subtest is labelled "underresponsivity/sensation seeking". Therefore, specific items in this subtest were

observed in order to differentiate participants with sensory seeking behaviour (e.g., seeks all kinds of movement that interferes with daily routine, seeks to make noise for noise's sake) from those presenting with underresponsiveness. The latter score poorly on items measuring low registration (e.g., doesn't seem to notice when face or hands are messy, leaves clothing twisted on body).

No marked differences were shown in participants' visual / auditory sensitivity, movement sensitivity and taste / smell sensitivity, with only a small percentage presenting with a "definite difference" in their sensitivity within these sensory systems.

Auditory input was found to be most disorganising for participants, particularly auditory filtering, which may have affected their ability to orientate and register to pertinent incoming auditory input appropriately and filter out irrelevant auditory input, which would have impacted their performance on the task at hand (Kielhofner, 2006).

A large portion of the sample fell within the "definite difference" range for low energy / weakness deficits. According to the theory of sensory integration, lowered energy levels may be indicative of a child with SMD going into sensory shutdown, occurring as a protective mechanism against severe overload when bombarded with multisensory stimuli. In contrast, a child with an underresponsive sensory profile and poor registration to sensation appears withdrawn and uninterested, requiring more salient input to register to it (James et al., 2011). As a result, his or her energy levels are affected, causing him or her to appear apathetic and "overly tired" Page 34:(Dunn, 1999). Conceptual models indicate the "low energy / weakness" subtest to be a more accurate reflection of underresponsiveness in the vestibular and proprioceptive domains (Miller et al., 2007d).

Based on the sensory processing difficulties in the sample, it was expected that participants' scores on specific items measuring negative behaviours associated with these underlying deficits would be impacted. This was seen on item 2, "'looks away from task to notice all actions in the environment at things he/she hears or sees", and item 7, "'poor maintenance of a seated posture" (Table 4.2). Participants displayed significant improvements (decreased post-intervention scores) on these two items, where the highest number of observations was recorded on the whole

scale. The change on these items can be linked to participants presenting problems with auditory filtering and low energy / weakness.

The use of passive self-regulation strategies predominated, given the higher percentages of participants found to have sensitivity to stimuli or low registration (related to their low or high threshold, respectively) on the Sensory Profile. Active self-regulation strategies were evident on the other end of the continuum although in a smaller percentage of the sample. Thus, the sample was heterogeneous in nature. That is, indicators of a high threshold for sensory input were present in combination with low thresholds for sensory input, with more than half the participants in this study having tactile sensory overresponsiveness (Figure 4.1).

Although Wilbarger and Wilbarger indicate that the DTPT should be applied to tactile defensive children, the pilot study by Kimball et al., which used salivary cortisol to measure the effects of the Wilbarger DTPT on sympathetic arousal, utilised a heterogeneous sample. Participants with both under- and over-responsive profiles were included in the study and positive results were found for both groups in that participants' cortisol levels moved in the direction of modulation expected toward a middle range. This indicated that they showed increased or decreased arousal according to their initial presentation of under- or over-responsiveness (Kimball et al., 2007). A heterogeneous sample was, therefore, recruited for this research and, due to the complexities and nature of a diagnosis of SMD and the various subtypes that present, it was difficult to find a homogeneous sample. Categories 4, 6 and 7 had no significant differences and low effect sizes, and few observations were recorded. The related behaviours in these categories did not appear to be affected by the DTPT and thus their inclusion in the behavioural scale should be revised for further investigation.

5.2.3 Sensory Processing and Behaviour in Neurotypical Children Compared with Co-Morbid Conditions

The prevalence of SMD in typical populations, referred to as idiopathic SMD (McIntosh et al., 1999a), is postulated to be between 5% and 16% (Ahn et al., 2004)., This increases substantially for clinical populations where prevalence is as high as 20% to 80% (Baranek et al., 2006, Baranek, 2002).

Sensory overresponsivity presents in conjunction with various other diagnostic categories, negatively affecting many children and adults (Kimball et al., 2007). Research estimates of sensory processing impairments in the paediatric population of children with learning disabilities are as high as two thirds (Schaffer et al., 1989). Over the past four decades, sensory modulation has been linked clinically to impaired arousal, inattention and problems with impulsivity (Ayres, 1972, Lane et al., 2010).

Since the participants of this study were specifically selected with known dysfunction in sensory processing, it was assumed that some participants were at risk for co-morbidities in conditions. Any signs of inattention, hyperactivity or anxiety that were present among participants were ascertained from the parent questionnaire or these were indicated as the reason for referral to occupational therapy. Although not clinically significant, the researcher was aware that these problems may have influenced the participants' behaviour in the study, affecting the results.

Just over half of the participants presented with signs of inattention and anxiety symptoms while nearly two thirds had increased activity levels. The high percentage of inattention and increased activity levels may have been due to participants presenting with undiagnosed co-morbid ADHD. Research has indicated that, although children with ADHD demonstrate overresponsiveness to sensation significantly more frequently than typically developing children (Mangeot et al., 2001), the behaviour of children with SMD often resembles ADHD in terms of difficulties with impulse control, attention, emotional regulation, and social skills. A diagnosis of SMD often initially precedes a diagnosis of ADHD (Stalker and Reebye, 2007).

A recent study in 2010 also indicated that ADHD should be considered not only in conjunction with SOR but that anxiety, cortisol, and electrodermal responses were used to differentiate SOR and ADHD. In both conditions the bottom-up processing differences were linked to faulty information processing caused by impairments in prefrontal cortex/hippocampal synaptic gating (Lane et al., 2010). Other preliminary evidence is available for the paediatric population linking sensory overresponsiveness to anxiety, since an inability to modulate incoming sensation

manifests in anxiety and other stress-related behaviours (Pfeiffer et al., 2005, Neal et al., 2002, Lane et al., 2010).

The researcher remained cognisant of the signs of inattentiveness, anxiety, and increased activity present in the participants when analysing their behaviour but did not distinguish in any way between ADHD and SMD given the research that has shown these disorders to be closely related and not easily differentiated.

The presence of anxiety may explain the exponentially high baseline cortisol levels found for the participant who could not be included in statistical tests run on cortisol data in this study. From the parent questionnaire the caregiver described this participant as having “extreme, chronic anxiety that pervades every aspect of life”.

Another participant in the study displayed writhing and continuous, irregular movements in his neck, mouth, face and shoulder. Although undiagnosed and not associated with major disability, this movement type disorder has recently been researched and is classified in the literature as the syndrome of mild Athetoid Cerebral Palsy (Morris et al., 2002).

5.3 THE EFFECT OF A SINGLE APPLICATION OF THE WILBARGER DEEP TACTILE AND PROPRIOCEPTIVE TECHNIQUE ON BEHAVIOUR AND SELF-REGULATION

The first objective of this study was to determine the change in non-desirable and self-regulatory behaviours present, measuring behavioural modulation of participants while engaged in an Activity protocol prior to and following administration of a single application of the Wilbarger DTPT. The effects of the Wilbarger DTPT on negative behaviour and self-regulation will be considered separately.

5.3.1 The Change Measured in Negative Behaviours Post-Intervention

Children with SMD face great difficulty in successfully overcoming the challenges of everyday life (Lane et al., 2000) and often experience impaired self-esteem, aggression, anxiety and depression (Pfeiffer et al., 2005). These emotional deficits limit their social interaction (Baker et al., 2008), impair their sensorimotor skills and lead to problems in self-regulation (Cohn et al., 2000, Ashburner et al., 2008). Decreased active exploration of the environment seen in these children results in a

lack of participation in sensory experiences, impacting negatively on their learning opportunities (Baranek, 2002).

Specific negative behaviours that stem from this over- or underresponsivity to sensation showed positive improvement after the participants in this study received the Wilbarger DTPT. The significant reduction of negative behaviours in category 1, “attention and readines for task” (Table 4.3), particularly on item 2, “looks around the room at things he/she hears or sees, distracted easily by external stimuli”, and item 7, “poor maintainance of seated posture”, was linked to participants’ sensory profiling (Table 4.2) where the highest percentage of participants scored within the “definite difference” range for their ability to filter auditory input affecting their ability to attend. Attentional symptoms have been described in the SMD phenotype related to difficulty filtering sensory stimuli (Mulligan, 1996) and in this study the majority of participants demonstrated significant improvement in terms of their distractibility to auditory stimuli within the environment, measured on item 2.

Similarly, decreased muscle strength and endurance (“low energy/weakness”), the second highest percentage of “definite difference” scores, improved significantly on item 7 with a marked decrease in the participants’ tendency to tire quickly and use poor postural adjustments. The participant who showed an increase on item 7, “poor maintenance of a seated posture”, was the participant who presented with mild Athetoid Cerebral Palsy, and who obtained a higher score on this item in the post-test, related to his poor postural stability.

Participants’ group behaviour as well as their perseverance and task completion improved significantly for behaviours observed in category 2, “behaviour in group”, and category 3, ”perseverance and task completion” (Table 4.2). Moreover, large effect sizes of over 1 were found for the change in behaviour in both categories indicating an improvement equivalent to more than 1 standard deviation. While the change on item 12, “demands to be in the spotlight”, and item 14, “gives up easily and fails to complete the task”, in these categories was not statistically significant, it can be considered clinically significant, as both items had large effect sizes with that for item 14 being over 2. This indicates participants’ behaviour fell into a more functional range post-test allowing them to participate in activities more effectively for all the items discussed above (Jacobson and Truax, 1991). These results

applied particularly to four of the five participants who obtained high scores for negative behaviour pre-test on these items. These participants all had sensory overresponsivity and were among those with “definite” tactile sensitivity. They also demonstrated the greatest reduction in negative behaviour post-test.

Again, a clinically significant change with a large effect size of just under 1 was found post-test on item 16, “transitioning between tasks withut completing given task” (Table 4.2). This means that the Wilbarger DTPT had a large impact on changing the behavioural consequences of sensory overresponsivity assessed by items 12, 14 and 16, with positive improvements noted in the post-test.

Similar results were found for the participants with overresponsivity in category 5, “ability to cope with new situation”, which had the largest effect size for any category (2.59). This was, however, based on a very small number of observations relative to categories 1, 2 and 3. Again, the researcher is of the opinion that the new and unfamiliar situation of the research environment elicited participants' fight, flight or freeze responses that can be accounted for by the theory that sensory overresponsiveness may result in over activation of sympathetic nervous system responses in the presence of non-noxious and unfamiliar stimuli. These reactions have been linked to unstable emotional responses (irritability, moodiness), poor socialisation, and rigid and controlling behaviour (Miller et al., 2007b).

Those participants with sensory underresponsivity may also have been blunted in their responses to a new situation due to their lack of inner drive for exploration or to initiate socialisation. Their behaviour is described as being self-absorbed, withdrawn and difficult to engage (Miller et al., 2007b). Participants with over- and underresponsivity all obtained higher scores on the items in category 5 in the pre-test but showed a reduction in these behaviours in the post-test, while the situation remained unfamiliar to them. The tasks used in the Activity protocol were all replaced with new, unfamiliar activities participants had not experienced. They all had difficulties interacting and coping with the new situation of the research environment for different reasons, which should be further investigated among a larger sample.

It was found that anxiety was an additional factor influencing the results for category 5 for participants with overresponsivity. The same five participants who displayed

negative behaviour on category 5 also scored more negative behaviour on item 25, “appears anxious, lacks confidence and withdraws”. These participants were all reported to have anxiety symptoms by their caregivers prior to commencement of the study. Four of these five participants showed marked improvement on this item and only one participant remained consistently anxious (i.e., no change) with a clinically significant difference indicated by an effect size of over 1 (Table 4.3).

The improvement in item 25, “appeared anxious, lacked confidence and seemed withdrawn”, is also clinically important as this is one of the treatment outcomes reported to be of greatest importance to parents of children with SMD. Parents perceived competence/self-esteem, social participation, and self-regulation as problems in which they would most like to see improvement (Cohn, 2001). Improvement in participants’ perceived competence/self-esteem could be seen in their improved behaviour in their ability to keep on with the task (item 14, “give up easily”), their need for less help on item 22, “mediation in the task”, and the reduction of behaviour on item 25, “appears anxious, lacks confidence and withdraws”. These specific behaviours were almost completely reduced in the post-test. Although statistical significance was not found due to fewer participants rated on these items, the large effect sizes of between 1 and 2 (Table 4.3) cannot be discounted. These large effect sizes show clinical significance for the effectiveness of the Wilbarger DTPT in improving negative behaviours linked to perceived competence/self-esteem. The changes seen in participants’ self-regulation are discussed below.

A recent systematic review of the performance challenges experienced by children who have difficulty processing and integrating sensory information, reported statistically significant correlations between sensory processing and social competence. The literature shows a direct link may exist between sensory processing and social performance. The studies reviewed provided evidence that children with poor sensory processing demonstrate decreased quantity and quality of play skills and social participation (Koenig and Rudney, 2010, Hilton et al., 2007). Given the strong correlation between sensory processing and social performance deficits reported in the literature, it is unusual that participants did not score on the items in category 6, “social interaction”. It may be because behaviours related to

social participation were under-represented on the scale used in our research, with only two items measuring this performance construct.

5.3.2 Overall Changes Observed in Self-Regulation Post-Intervention

The negative behaviours for participants in this study that decreased significantly were related to concentration, attention, disruptive behaviour, task completion or avoidance, rapid transitioning, and withdrawal or anxiety. Adequate self-regulation provides a foundation for these higher-order skills required for participation in social and functional activities (Schaaf et al., 2003). This suggests that the improvement noted in these behaviours (i.e., decreased post-test scores) in this study can be linked to overall improvement in participants' self-regulation. Participants were able to display adaptive responses and participate in the Activity protocol more successfully (Dunn, 2007).

Participants with low sensory thresholds showed a tendancy to notice and respond rapidly to sensory stimuli in the pre-test, which was expected according to Dunn's theory of neurological thresholds. However, these participants showed a reduction of this behavioural tendancy in the post-test. Compared to the pre-test, their systems activated less readily to similar sensory events. In contrast, participants with high thresholds missed stimuli that their peers noticed easily, or appeared withdrawn in the pre-test. After receiving stronger, more intense input through the Wilbarger DTPT they appeared more activated, as measured by their improved behavioural responses (Dunn, 2007). The changes in behaviour observed in the latter group were not as marked as those seen for the group with low sensory thresholds (i.e., sensory overresponsiveness), however.

Active self-regulatory behaviour was seen to decrease in the sample on item 34, "uses proprioceptive/tactile/oral input", the type of regulation for which the majority of observations were made (Table 4.4). Participants needed to obtain less somatosensation, in particular, in the post-test phase compared to their use of this sensory input in the pre-test phase. Firm touch pressure applied to the surface of the skin and joint proprioception (compressions or approximation of major joints) are both sources of calming and organising sensory input to the nervous system, effective in regulating one's nervous system (Kandel et al., 2000). Therefore, once participants obtained this input through the Wilbarger DTPT, they needed less deep

pressure and proprioceptive sensation and were observably more regulated as a result. These results were not significant either statistically or clinically as there was only a small effect size seen.

The findings are supported, however, by a study conducted among preschoolers with pervasive developmental disabilities and school-age children with ADHD. The researchers tested the effect of similar sensory inputs (touch pressure and proprioception) applied through the use of weighted vests in assisting children to organise themselves and focus better on their school work. The children's negative behaviours decreased, their attention improved and their work productivity reportedly increased when wearing the weighted vests (Fertel-Daly et al., 2001, VandenBerg, 2001).

Over half the participants in this study also used less proprioceptive, tactile and/or oral input to self-regulate. The participants whose scores on self-regulation items decreased, all had "probable" to "definite differences" in sensitivity to stimuli on the SP (indicating a diagnosis of sensory overresponsivity).

The same four participants whose behaviour improved the most for total scores on negative behavioural items, required less somatosensory input in the post-test to counteract their sensory sensitivity and regulate their systems. They also demonstrated the largest change between pre- and post-test scores on item 34, "uses proprioceptive/tactile/oral input". This indicates that the most effective outcome was obtained in calming yet organising the sensory systems for this group of participants with definite sensory sensitivity, once proprioception and deep pressure tactile input was gained through the Wilbarger DTPT. The effect was immediate since these participants needed less of this type of sensory input in the post-test phase after a single Wilbarger DTPT application.

The change in self-regulatory behaviour for item 33, "uses movement input", and item 35, "uses auditory input", both show non-significant increases in the post-test phase. The scores of 11 participants showed an increase in their use of movement, or auditory input, to self-regulate in the post-test (Figure 4.2) . The two participants who showed the greatest increase in self-regulatory behaviours displayed noticeably reduced levels of distractibility within their environment (on item 2). Both participants scored in the "definite difference" range for inattention and distractibility

on the SP. Therefore, it appears that after receiving the intervention, the increased self-regulatory behaviour of these participants appeared to most improve their concentration, attention and readiness for tasks.

Only two participants showed regression of behaviour in more than one item in this catatgory. Both displayed more observations on item 33, "uses movement input", and item 34, "uses proprioceptive/tactile/oral input", after receiving the intervention. They were still not able to achieve a self-regulated state even with added sensory input, which impacted on their behaviour on other items. Their SP scores indicated more "definite differences" in low registration and one participant, in particular, was observed as having a low level of arousal in the post-test. This participant remained at one activity for the entire duration, failing to notice other opportunities and his awareness of the environment and engagement in the activity was poor. This participant's salivary cortisol levels were the lowest in the sample at baseline and showed no change after receiving the intervention. This may explain his consistently poor self-regulation, with no improvement noted in the post-test phase of the study after the DTPT had been administered, indicating the lack of effect from a single application of this technique for this participant.

Therefore, differences were seen in the pattern of self-regulatory behaviour used by the subgroup of participants with sensory overresponsivity and low neurological thresholds compared to those with sensory underresponsivity and high neurological thresholds. Differences between these two groups of participants were also found for the changes seen in salivary cortisol levels pre- and post-test across the sample. However, changes in salivary cortisol (arousal) and self-regulation were not associated (r=-0.32).

5.4 THE EFFECT OF A SINGLE APPLICATION OF THE WILBARGER DEEP TACTILE AND PROPRIOCEPTIVE TECHNIQUE ON SALIVARY CORTISOL

The second objective of the study was to evaluate the change in salivary cortisol levels tested before and after children received a single administration of the Wilbarger DTPT intervention.

5.4.1 The Change Measured in Salivary Cortisol Levels

An individual's ability to adapt to changes in the environment is regulated through the autonomic nervous system by means of motor, sensory, visceral, and neuroendocrine modulatory functions, through its sympathetic and parasympathetic branches. These two branches function together to allow self-regulation and adaptation to environmental changes. While the sympathetic branch produces immediate phasic fight-or-flight reactions, the parasympathetic branch regulates recovery from a stressful stimulus and by so doing, maintains homeostasis and self-regulation (Schaaf et al., 2003).

Children with SMD who exhibit over- or underresponsiveness to sensory stimuli based on the functioning of their autonomic nervous system, have an inability to restore homeostasis or self-regulate following an environmental stressor. This impacts on their ability to participate in daily activities (McIntosh et al., 1999a).

Therefore, it was expected that the salivary cortisol levels of the participants in the study would be affected by the presence of their identified over- or under-responsiveness and would differ depending on the pattern of sensory responsiveness with which the participants presented. All the values for cortisol fell into the expected range, except for the one participant whose results were not analysed (Salimetrics, 2012).

It was, therefore, not realistic to consider the sample as a whole and based on the study by Kimball et al., the mean values for change of cortisol levels was considered, depending on the change up or down (Kimball et al., 2007).

The mean values of cortisol in the saliva of 12 participants in the sample decreased from pre-test to post-test indicating that their cortisol levels decreased after the Wilbarger DTPT was administered. This group of participants all had sensory sensitivity with definite sensory processing deficits seen from their low total test scores on the SSP. Thus, it appeared that the Wilbarger DTPT modulated their cortisol down to a more middle range, as was expected, according to what the technique was theoretically designed to do. Previous findings have reported this change, explaining that higher baseline levels decreased after the DTPT was given to participants but did not link it to a specific subtype of SMD, as in this study (Kimball et al., 2007).

Eight participants who showed the lowest concentrations recorded across the sample for baseline cortisol measures were participants with underresponsiveness. These participants' cortisol levels either increased in the post-test or stayed unchanged. This result is supported by the study by Kimball et al., that found lower baseline salivary cortisol concentrations levels increased to a more middle range after these participants received the Wilbarger DTPT (Kimball et al., 2007).

These findings indicate that the Wilbarger DTPT can be associated with modifying salivary cortisol levels in the direction of modulation expected. In other words, for participants with sensory sensitivity, their sympathetic nervous system activity was higher at baseline, as is expected of individuals who remain in a state of constant stress and vigilance in their environment.

Children who are behaviourally overresponsive to sensation have been found to have overactivity in their sympathetic nervous systems, which has been correlated to abnormal behavioural responses (McIntosh et al., 1999a, Miller et al., 2001). Hence, for these participants (60% of the sample) a statistically significant downward trend was found in their cortisol levels and, therefore, it is assumed in their arousal (stress) levels, after receiving the intervention (Table 4.5).

These results confirm that, in these participants, overresponsiveness affected sympathetic arousal. The cortisol levels found indicate that the mechanisms of sensory overresponsivity overlap with the processes involved in typical defence, stress, anxiety, and fear. Sensory overresponsive responses mimic the normal fear-based response physiologically where the stimulus is misidentified by the amygdala (Wilbarger and Wilbarger, 2012a, LeDoux, 2003). Research has identified that the physiological markers of sensory overresponsiveness relate specifically to the misevaluation of noxious stimuli as "negative" or "harmful" leading to defensive behaviour (fight, flight or fright), increased responsiveness of the autonomic nervous system, poor habituation (McIntosh et al., 1999), poor parasympathetic regulation (Schaaf et al., 2010a), and poor sensory gating (Davies and Gavin, 2007) as well as negative affect (fear, anxiety, stress), and distortions in pain processing (Wilbarger and Wilbarger, 2012a).

It can be assumed that increased responsiveness, poor habituation to stimuli, and escalation of arousal, which lead to heightened levels of sympathetic nervous

system activity explain the raised salivary cortisol levels found for these participants in the pre-test phase of our study. Some of their negative behaviour resulting from this increased sympathetic nervous system activity showed significant improvements when their sympathetic arousal levels, measured by decreased salivary cortisol levels, dropped in the post-test phase.

The group of participants whose sensory profiles indicated underresponsiveness, presented with lower cortisol concentrations in their saliva at baseline, assumed to be related to lower levels of sympathetic arousal. Their cortisol levels changed significantly, increasing to more normal levels (25% of the sample), again modulating their arousal (hyporesponsiveness). However, for some of these participants in the latter group with underresponsive profiles, no change was found in their cortisol levels (15% of the sample).

Therefore, in participants presenting either with low registration or “pure” tactile defensiveness (those with defense against sensory events), or with high registration to sensory stimuli (tactile defensiveness was seen in combination with underresponsiveness), baseline cortisol concentrations gained a more modulated state of sympathetic arousal after receiving the Wilbarger DTPT. Cortisol levels moved in the direction of modulation expected, toward a more middle range, replicating results from the previous pilot study (Kimball et al., 2007) discussed.

5.4.2 A Reduction in Behaviour and Salivary Cortisol Associated with Tactile Defensiveness

From the above discussion, it is clear that the five participants who presented with definite tactile defensiveness (23% of the total sample) showed the greatest change in behaviour after receiving the Wilbarger DTPT.

According to subtypes of SMD proposed by Miller and her colleagues, these participants fell into the subtype of sensory overresponsiveness (Miller et al., 2007b). This is interesting when considering that the Wilbarger protocol was originally designed to treat children with sensory overresponsiveness specifically in the tactile system. These participants did present with higher baseline cortisol levels related to being in a state of constant “stress” and hypervigilance, resulting in heightened sympathetic nervous system activity. They demonstrated a significant reduction in negative behaviours when compared to the rest of the sample.

A similar significant result was not found for their cortisol levels, as one participant had an increase in cortisol levels while the others had a decrease in the post-test phase. This occurred because, even though these participants with “definite differences” in tactile sensitivity and touch processing fell into the “sensory sensitive” and “sensory avoidant” quadrants on the SP, one participant also obtained more “probable differences” for low registration in his quadrant scores. This participant presented with a mixed sensory profile with a component of low registration. His low registration can be linked to the post-test increase in cortisol measured in his saliva, as was consistently found across the rest of the sample for participants with low registration. This differed from the other four participants whose cortisol levels were higher at baseline, and all went down post-intervention, as was expected.

All of the participants with tactile defensiveness displayed more negative behaviours pre-test. This is supported by literature, which hypothesises that in the presence of tactile sensory overresponsivity, adaptability and performance can be constrained in all areas of function impacting on behaviour. Evidence suggests that children in such cases experience difficulty processing and integrating sensory input (Koenig and Rudney, 2010). Rogers, Hepburn, and Wehner (2003) found that there was a significant relationship between sensory reactivity and the acquisition of adaptive behavioural skills (Rogers et al., 2003) and, as a result, these children display more difficulty with functional behaviours and participation. The performance deficits seen in the child who is overresponsive to tactile stimulation, have been reported to consistently impact negatively on family routines and activities of daily living (ADLs) (Reynolds and Lane, 2008).

Participants with tactile defensiveness all scored high on negative behaviours for item 14, “gives up easily, fails to complete the task”, and item 16, “transitioning between tasks without completing given tasks”, in the pre-test and showed marked reductions on these items in the post-test. On item 14 particularly, the tactile sensitive children were among the participants who showed the greatest change in this behaviour. These items can both be linked indirectly to hyperactive-impulsive type behaviour associated with the sensory overresponsive child, preventing completion of tasks and leading to rapid transitioning between activities. This is

related to the child's heightened vigilance and fight-or-flight behaviour (Miller et al., 2007b).

This hyper-vigilance can result in negative behaviours since children with sensory overresponsivity actively seek to escape sensation they perceive as potentially harmful. They may become restless or even aggressive (striking out) in their attempt to move and avoid the sensory input that they experience as dangerous. Therefore, their resultant behaviours appear as hyperactive-impulsive type symptoms and may also be linked to underlying differences in the systems responsible for reactive control. However, no specific CNS loci connected to sensory overresponsivity have been identified (Lane et al., 2010).

5.4.3 The Association Between Behaviour and Salivary Cortisol Changes

The third objective of the study was to determine whether there was any association between the change in behavioural modulation and change in salivary cortisol levels, in children with SMD after a once-off administration of the Wilbarger DTPT.

A very weak association was found between behavioural and physiological measures even though both showed significant changes after participants received the Wilbarger DTPT. Several explanations for this discrepancy and weak correlation ($p=0.02$) are plausible.

Firstly, the study measured a once-off, short-term response rather than a change over time with repeated application of the DTPT. Therefore, this did not allow long-term physiological adaptation to take place, in which case, biochemical and cellular changes may have yielded a greater correlation to behavioural changes.

When examining neuroscience evidence for sensory-based occupational therapy, an evidence-based review indicated that neuroplastic change occurs in the CNS when the child actively engages in meaningful sensorimotor activities. Conversely, passively applied sensation (e.g., passively imposed touch) does not appear to provide the same affordance for integration and neuroplasticity (Lane and Schaaf, 2010). However, research over the past two decades that points to the power of intense, subpainful somatosensory-based interventions shows how with repeated application of such input, long-term neural plastic changes can occur (Pert, 1997,

Field, 1998, Bundy et al., 2002, Melzack, 1996). Repeated application of somatosensory input provided through the Wilbarger DTPT is believed to improve homeostasis, reduce stress and pain, and regulate behaviour. Long-term adaptation is assumed to occur at a cellular and biochemical level first and then on a behavioural level, in much the same way as these somatosensory-based interventions reduce chronic pain (e.g., acupuncture and transcutaneous electrical nerve stimulation known as TENS).

Consequently, a relationship between behaviour and physiological functioning may only be found over the long-term. This means that after sufficient time, physiological changes affect changes in behaviour. The scope of this study did not allow for such a relationship to be determined because results for behaviour and salivary cortisol levels (sympathetic arousal) reflect immediate, short-term changes measured.

As nervous system changes occur over time, the individual's sensory processing and, subsequently, his or her behaviour will change. According to sensory integration theory, through successfully meeting ongoing challenges the child learns to organise new behaviour accordingly, providing increased skill and motivation to engage in further more complex, challenging activities (Paul et al., 2003).

Secondly, the participants within the sample were not homogenous since the sample consisted of children with sensory overresponsiveness and sensory underresponsiveness. It was also evident from the results that these behavioural subtypes of SMD affect the results, since paricipants exhibit different patterns of physiological activity.

This was supported in a study that investigated the relationship between physiological measures and measures of sensory-related behaviours. Clinical groups of children with Autism Spectrum Disorder and Sensory Modulation Disorder were compared and differentiated from typically developing children. However, the study also found no association between these two variables (i.e., behavioural and physiological measures of sensory processing) and stated the reason for this finding to be the lack of homogeneity across the sample. The three different subtypes of SMD were found in both clinical groups. The authors of the research concluded that the differences in the physiology of individuals based on behavioural subtypes (sensory overresponsivity/sensory underresponsivity/ sensory seeking) may have

led to the lack of relationship found between physiological data and parent report measures of behaviour (Schoen et al., 2009).

Finally, because SMD is related to grading one's responses to sensations from the environment, patterns of responsiveness can vary throughout the day and from day to day, depending on the situation (Zero to Three, 2005, Miller et al., 2007b). Thus, each individual's unique pattern of responsivity may have caused the wide variance seen in the results for the behavioural and physiological changes observed, when comparing subtypes and individual responses. The large standard deviation of 26.48 found for the mean decrease in negative confirms this variance in the reduction of negative behaviours. The behavioural and physiological changes reported in this study are still important to clinical practice even though only short-term observations are provided, with no correlation found between these two dependent variables.

5.5 IMPLICATIONS FOR PRACTICE

As discussed, an increasing number of children are experiencing SMDs - as many as 5-16% within the general population (Ahn et al., 2004), consistent with Ayres's initial estimation (Wilbarger and Wilbarger, 1991, Wilbarger, 1995). Even higher figures (as many as 80-90%) are reported for children on the autistic spectrum (Rogers and Ozonoff, 2005, Tomchek and Dunn, 2007). In light of this and the widespread associated occupational performance deficits found in children with SMD, it is a growing concern that high quality, empirical evidence for the treatment of this population is limited (Miller et al., 2007e, Miller, 2003a). Occupational therapists using the Wilbarger DTPT in practice need empirical evidence of its effect on clients, evaluated through objective means.

The results from this research indicated the greatest improvement in behaviour was seen in individuals with sensory sensitivity or defensiveness, this being the target population for the Wilbarger DTPT. Wilbarger argues that sensory overresponsiveness is so disruptive to a client's life that it should be a primary concern for intervention, though it is difficult to treat (Wilbarger and Wilbarger, 1991). The Wilbarger approach to treating SMD intends to improve clients' ability to

participate more fully in daily occupations by treating the nervous system and, therefore, modulating behaviour.

The changes observed in this study were short-term. It should be reiterated that the DTPT was not designed to be recommended in isolation but rather, as part of a comprehensive intervention plan integrated into daily life. The focus should be on improving performance and increasing roles of independence in all activities of daily living (Wilbarger and Wilbarger, 2012a). Wilbarger and Wilbarger suggest that using the protocol in the incorrect way, using the wrong brush or using a single application of the DTPT may have a negative effect on the client's nervous system.

Although the Wilbargers' concerns related to use of a once-off application may be true to prevent any likely harm and to achieve maximum benefit, the results from this small study explicate why use of single applications have persisted in practice. Modifications to this procedure are made in this way by many occupational therapists who prescribe it as a single application to assist clients through difficult sensory experiences imbedded within daily life. This variation of the Wilbarger DTPT is thus recommended and often used as a "practical" means for improving clients' arousal levels for coping with daily events and transitions (Kimball et al., 2007). In this way, occupational therapists consult teachers and families to identify strategies to meet the child's sensory processing needs before or during challenging routines. By so doing, sensory processing knowledge is used as a tool to provide strategies for families to implement as part of their routines (Dunn, 2007). The Wilbarger DTPT can be used in this way to increase the child's chances to manage more situations successfully and continue participating in their everyday activities.

The goal of the Wilbarger protocol is to maintain optimal arousal. The "optimal level of stimulation" theory states that each person needs an optimal level of stimulation to reach an optimal level of arousal required for cognitive, motoric activity and positive affective tone (Zuckerman, 1979). Sensory input or sensory- based activities are more effective when a child's arousal is maintained at an optimal level (Dunn, 2007). Wilbarger and Wilbarger believe that the more times the nervous system experiences optimal adaptive levels of arousal, the easier it will become for that client's nervous system to return to those levels (Wilbarger and Wilbarger, 2012a). Therefore, even though single applications of this technique create short-

term changes in behaviour and sympathetic arousal, “maintenance” is a key aspect to the long-term effectiveness of the Wilbarger DTPT.

Ideally, the deep pressure and joint compressions should be administered every 90 minutes to two hours in order for the protocol-based procedure to promote the best neurochemistry. This means that graduations in frequency and intensity are key to long-term neural adaptation occurring, where changes in the nervous system may be more permanent. Less frequent application and a lack of appropriate pressure are the two factors that clinical experience has shown reduces the efficacy of this approach (Bundy et al., 2002).

5.6 LIMITATIONS OF THE STUDY

This study utilised a fairly small convenience sample of participants with SMD, with no control group for comparison to children with typical sensory processing. The sample size was small relative to the variables studied across the different patterns of sensory processing present among participants. For this reason, the lack of a larger sample did not allow for further exploration of the variations seen between the subtypes of SMD, in terms of the changes measured in their behaviour and physiological functioning. The results of the study, therefore, need to be generalised with care to a larger population of children with SMD.

In addition, given the young ages across the sample it is possible that secondary diagnoses may not have yet been diagnosed in participants at their point in development. It is therefore possible that co-morbid conditions (for example, ADHD or anxiety) were undiagnosed in some of the children.

No measure was used to assess behavioural issues identified by parents and teachers to determine the correlation between negative behaviours seen in this study and those that present in other environments. The Conner’s Rating Scale-Revised was used in the research by Kimball et al. to evaluate problem behaviours in terms of participants’ conduct, cognitive, anxiety and social problems (Kimball et al., 2007). This may have been an effective step in the method of our study to provide further correlations of behaviour to real life situations. The total test score from the SSP has been found to be a sensitive and appropriate outcome measure (McIntosh et al., 1999, Miller et al., 2007f). Although the scale utilised to evaluate

behaviour during the Activity protocol had been field-tested with a similar sample using similar procedures and found to assess meaningful change, it was not a standardised outcome measure.

The Activity protocol itself may not have sufficiently mimicked a natural environment, which consistently elicits stress and sympathetic responses from children due to exposure to multiple sensory inputs. Activities selected closely resembled those found in the classroom environment; however, stimuli were carefully administered in a controlled manner. The goal of the Activity protocol was to provide familiar daily sensation that would challenge participants' sensory processing and behaviour but at the same time not create undue stress. However, the fact that the observations were done in a group session, the anxiety caused by there being video cameras set up around the room and the fact that the occupational therapists were not known to all the participants may have caused heightened stress and anxiety for some of the children. The nature of the Activity protocol may need to be explored further for it to be as close to normal activity as possible.

5.7 SUMMARY

Behaviour improved overall with the most positive change seen in participants' concentration and attention, behaviour in a group and their perseverance and task completion. These were the behavioural categories for which the decrease measured in post-intervention scores was significant. The large difference seen in participants' ability to cope with a new situation (effect size 2.59) should also be considered by practitioners utilising this technique.

Interestingly, the children with tactile defensiveness showed the greatest positive change in these behaviours. The decrease in their behavioural scores overall was significantly more than the decrease observed in the rest of the sample, for a reduction in negative behaviour. Maximum benefit may, therefore, be seen in these individuals. The Wilbarger DTPT may be associated with assisting their ability to engage more effectively in activities of daily living, education, leisure or play activities and improve their social participation with consistent improvement in these behaviours over time.

Although self-regulation decreased in the sample on the whole, after participants received somatosensory input from the Wilbarger DTPT, this decrease was not significant. Perhaps over time, as neural adaptation takes place, participants' self-regulatory behaviours will show more marked changes, from which recognised patterns may be described. Only 15% of our participants showed no change in their salivary cortisol levels and, linked to this, their arousal levels. Therefore, most of the sample of 20 participants showed a physiological response (i.e., change in sympathetic arousal) to the intervention technique. Increased or decreased cortisol levels were found, corresponding to participants' patterns of responsivity and subtypes of SMD.

The effect of the whole Wilbarger protocol, as it was intended to be prescribed, should still be investigated. However, this study supports occupational therapists' long-established clinical reasoning and observations that the Wilbarger DTPT modulates the state of clients' sympathetic nervous systems. The long-standing associated behavioural changes that have been described by many case studies are also documented in this study, with specific reference to those behaviours that show the greatest change in the short-term (i.e., immediately after application of the technique).

The present study contributes new information to the existing body of literature available on this topic, moving the empirical basis of the profession forward. The findings build on the results reported in the initial pilot study that used salivary cortisol to measure the effects of this Wilbarger protocol-based procedure (DTPT) on sympathetic arousal (Kimball et al., 2007). This pilot study did not report any behavioural changes but stated the importance of future studies documenting this, in order to determine whether changes in behaviour are consistent with sympathetic modulation responses. Although changes in behaviour were not associated with changes in salivary cortisol (sympathetic arousal) in our research, the results showed significance for both. Therefore, the Wilbarger DTPT is associated with short-term changes in clients' behaviour and normalisation of autonomic responses, producing a more modulated state.

CHAPTER 6: CONCLUSION

6.1 CONCLUSION

Intervention protocols like the Wilbarger approach are directed toward assisting the client in achieving internal adaptation. When this occurs on a physiological level first, improved overt adaptive behaviours are then seen overall. Thus over time, as the brain and nervous system learn to process, organise and integrate sensory information, the child exhibits more appropriate reactions to sensation. When these reactions match the task demands, social supports, environmental contexts, and cultural expectations of a situation, the client may experience improved occupational and role performance (Bundy et al., 2002, Cohn et al., 2000, Lane and Schaaf, 2010).

The present study used objective methods and provided preliminary support for the effectiveness of the Wilbarger DTPT. After administration of this protocol-based technique (DTPT), the behaviour and salivary cortisol levels of our study participants showed significant results when measuring short-term responses. Although the changes observed in these two variables were not related, the DTPT still had an effect on both.

The results indicate that improved responsiveness, both in terms of behaviour and sympathetic arousal, was noted in clients with SMD (with over- and under-responsivity) after receiving the intervention. For both groups of children with overresponsiveness and underresponsiveness to stimuli, the Wilbarger DTPT was associated with modifying salivary cortisol levels and, in turn, arousal or stress levels theoretically. Specific behaviours in our participants showed improvement after the intervention, which may have resulted from better responsiveness of our clients' CNS to environmental stimuli, though no correlation was found.

Significant changes were found for negative behaviours related to participants' concentration, attention, and readiness for a task, their behaviour in the group, and their perseverance and task completion. However, the Wilbarger DTPT was found to have the greatest effect (as seen from the large effect sizes recorded) on behaviours associated with sensory overresponsivity specifically, and those

measuring participants' perceived competence and self-esteem. The latter is an important outcome measure for parents of children with SMDs.

The goal of the Wilbarger approach is to improve clients' sensory responsivity, motor competence, social behaviour, and meaningful participation in occupations of daily life, including play and school tasks for children (Wilbarger and Wilbarger, 2012a, Schaaf and Nightlinger, 2007). The documented improvements seen in specific areas of behaviour measured by this study, provide promising results for occupational therapists to achieve this goal and ameliorate performance deficits in children with SMD when utilising the technique.

Participants' ability to self-regulate following administration of the intervention improved. This was seen from their ability to maintain a more appropriate arousal state and level of consistent performance, as measured by their improved behavioural scores (decreased negative behaviour) on the scale in total. This improvement in arousal and behaviour provides evidence to support improved underlying regulatory processes after intense somatosensory input is gained from the Wilbarger DTPT; however, the overall effect size (0.01) was small.

Salivary cortisol is an effective measure of the stress response and is directly related to sympathetic arousal, as validated by past research (de Haan et al., 1998, Bear et al., 1996). This non-intrusive method allowed us to measure physiological changes in the young participants included in our study. An apparent relationship was established between application of the Wilbarger DTPT and the modulation of cortisol levels. In all participants in the study, cortisol levels moved toward a middle range in the direction expected, based on previous findings (Kimball et al., 2007). The results from the pilot study by Kimball et al. and those reported by this research confirm that children whose baseline cortisol levels were higher on pre-test decreased on post-test. In contrast, those whose cortisol levels were lower on pre-test increased on post-test.

This study further linked these apparent changes to the type of SMD the child presented with at baseline, to explain how cortisol moved in the direction of modulation for all participants. This was related to the participant having either sensory underresponsivity or sensory overresponsivity. In the presence of underresponsivity, lower baseline cortisol levels were recorded, increasing to higher

levels after receiving the intervention (demonstrating increased arousal, alertness). In the presence of overresponsivity, higher baseline cortisol levels were measured (presenting with heightened stress), decreasing to lower levels subsequent to receiving the intervention (displaying decreased arousal, stress).

Despite the differences observed between SMD subtypes and individual responses, those with sensory overresponsivity showed the best response to the DTPT. Behavioural overresponsivity to sensation and the apparent atypical integration of multisensory input that accompanies this, is seen in children with sensory overrsponsiveness (Brett-Green et al., 2010). This places them at risk for experiencing challenges in their interaction and profoundly reduces their successful participation in home, school and community environments.

Specifically, participants with tactile defensiveness in our research showed the greatest reduction in the negative behaviours that are associated with reducing successful performance and limiting participation, according to the trend that developed. Occupational therapists utilising this protocol should note that the Wilbarger approach was developed to treat sensory overresponsivity, with the most positive results found for these clients in our study (i.e., greatest change in behaviour). The occupational performance of such clients may, therefore, be positively impacted as a result of the marked improvements seen in their behaviour overall.

The use of sensory-based interventions in the treatment of sensory overresponsiveness is complicated by the unique behaviours that these individuals exhibit. In particular, individuals with sensory overresponsivity avoid novel activities and sensory input in general. This makes it difficult to expose a client to a new sensory experience such as the Wilbarger protocol. Therefore, the protocol should be administered by a trained occupational therapist to ensure that it is done so positively, with as little anticipatory anxiety created for the client as possible. Care should be taken to use the correct procedure with adequate amount of pressure applied (Bundy et al., 2002).

Occupational therapy, in particular, needs valid and reliable research to increase the accuracy of treatment decisions and verify referrals and intervention techniques employed for each client. Though clinical reports provide much evidence of the

effectiveness of the Wilbarger protocol, a lack of high quality evidence exists to support the use of this approach with children. Studies are, therefore, needed that investigate this protocol using more rigorous, scientific research methods with higher level study designs. This is especially important in light of the widespread, popular use of this regime, according to the high numbers available from surveyed data corresponding to its use in practice (Sudore, 2001).

Research should utilise outcome measures that are standardised and have strong psychometric properties, investigating the current topic in larger, homogenous samples and where possible co-intervention should be controlled for. These studies must focus on providing data related to the exact implementation of the Wilbarger protocol, so that precise treatment fidelity can be carried over between studies (Weeks et al., 2012). This will strengthen the body of knowledge and provide support for the Wilbarger protocol as a specific targeted intervention approach in the treatment of sensory modulation disorder.

The effects of the DTPT used on an as-needed basis should be compared to the effects of the whole Wilbarger protocol when implemented as it was intended to be prescribed, with repeated frequent application. Its effect on the different subtypes of SMD should be compared among a larger sample of the population. This may clarify possible patterns of physiological activity among the different subtypes of SMD. This may also confirm whether an association can be found between physiological variability and response to sensation or change in behaviour among the different subtypes of SMD after receiving the Wilbarger DTPT.

The World Health Organisation (WHO) advocates studies that investigate restrictions in social participation and functional performance from a multi-faceted perspective. These studies should also examine the underlying impaired mechanisms that cause limitations in participation (World Health Organisation, 2007). The study here reports on underlying physiological functioning, specifically sympathetic nervous system activity, in children with disturbances in sensory modulation linked to behavioural responsiveness to sensory stimuli.

To conclude, the objectives of this research were met and the null hypothesis was not entirely proven. The Wilbarger DTPT does have an immediate influence on negative behaviours overall and specifically pertaining to “concentration, attention

and readiness for task", "behaviour in group" and "perseverance and task completion", where statistically significant changes were seen in these behaviours. The change reported in participants' salivary cortisol levels, and therefore, their sympathetic arousal was significant. The null hypothesis is rejected for these significant differences found in negative behaviours associated with SMD and salivary cortisol changes measured after a once-off application of the DTPT. However, due to no significance found overall for the remaining behavioural categories and for participants' self-regulation, the null hypothesis that the Wilbarger DTPT does not influence these behaviours or change self-regulation is accepted.

This systematic research provides support for the short-term efficacy of the Wilbarger DTPT in changing behavioural and physiological responsiveness. The modified negative behaviours and sympathetic nervous system changes that resulted from a single application of the DTPT, reflect occupational therapists' clinical observations of its effect when used in this manner. The results offer preliminary evidence supporting the use of the Wilbarger technique in the treatment of sensory overresponsiveness. This evidence promotes best practice by specifying the population for whom this therapeutic approach can successfully be used with. However, due to the plethora of unanswered clinical questions related to the method and application of this approach, occupational therapists should exercise clinical judgment and take care when implementing the protocol in practice. Systematic observation and documentation of behavioural changes seen in their clients are advised.

6.2 RECOMMENDATIONS FOR FUTURE RESEARCH

This research showed the most favourable results were found for participants with tactile sensory overresponsivity. The DTPT should, therefore, be investigated among a larger sample including individuals with the different subtypes of SMD to confirm the result. This would determine whether the Wilbarger DTPT does, in fact, have the greatest effect on changing behaviour in this group of the population, looking specifically at tactile defensive children. Diagnostic specificity will allow targeting of interventions to particular diagnostic subtypes (Miller et al., 2007b).

Use of the Sensory Over-Responsivity scale would be an effective measure for differentiating children with this subtype. These scales are evidenced-based and measure sensory overresponsivity across seven sensory domains, combining an examiner-administered performance measure as well as a subjective caregiver-report (Schoen et al., 2008). If future research is able to report a strong correlation between children with sensory overresponsivity and a more marked improvement in the behaviour of these children when receiving the DTPT, it would further support the use of this protocol-based technique in the treatment of sensory overresponsiveness.

Other studies have shown that disruptions in an individual's parasympathetic nervous system functioning affects his or her ability to maintain a focused and calm state when sensations of everyday life are encountered, affecting his or her activity participation (Schaaf et al., 2003, Schaaf et al., 2010a). Therefore, research should also clarify the relationship between parasympathetic nervous system functioning and abnormal sensory responsiveness, relating this to behaviours seen in children with SMD. This will provide data that may guide occupational therapy interventions that help a client maintain and regain homeostasis and self-regulation.

Further investigation should compare the effects of the DTPT used as a single application to that found when the whole Wilbarger protocol is used as it was intended to be carried out. The technique's developers teach in their workshops that best practice for treating individuals with sensory overresponsiveness is the comprehensive application of all three components of the protocol. Clients are most likely to show the greatest improvement when the correct procedure is followed in its administration and when consistent adherence to the programme is maintained (Wilbarger and Wilbarger, 2012a).

Future studies must determine whether occupational therapists using this procedure as and when needed to reduce certain behaviours, risk preventing more permanent changes in their client's behaviours, which occurs from neural adaptation when the protocol is used correctly (Wilbarger and Wilbarger, 2012a). Otherwise, is the short-term effect gained from use of a single application short-lasting and, therefore, does not influence long-term changes and neural adaptation, as can be expected when using the whole protocol as prescribed.

An important clinical question to answer is what duration, frequency and intensity results in permanent changes to the sympathetic nervous system that would consequently lead to permanent reductions in negative behaviours. Maintenance of gains over time should be considered by researchers to determine a meaningful dosage rate. This is important for prescribing an optimal daily amount and weekly frequency of the DTPT, that will be known to allow measurable change to take place even though individuals' responses may differ (May-Benson and Koomar, 2010).

REFERENCES

AHN, R. R., MILLER, L. J., MILBERGER, S. & MCINTOSH, D. N. 2004. Prevalence of parents' perceptions of sensory processing disorders among kindergarten children. *American Journal of Occupational Therapy,* 58**,** 287-293.

AMERICAN PSYCHIATRIC ASSOCIATION 2000. Diagnostic and Statisical Manual of Mental Disorders, Fourth Edition, Text Revision. Washington, DC: American Psychiatric Association.

ASHBURNER, J., ZIVIANI, J. & RODGER, S. 2008. Sensory processing and classroom emotional, behavioral, and educational outcomes in children with autism spectrum disorder. *American Journal of Occupational Therapy,* 62**,** 564-573.

AVANTI EDUCATIONAL PROGRAMS. 2013. *A review of the literature on sensory defensiveness and the Wilbarger approach* [Online]. Panorama City. Available: http://wilbarger.tripod.com/id5.html [Accessed 6 May 2013].

AYRES, A. 1963. The development of perceptual-motor abilities: A theoretical basis for treatment of dysfunction. *American Journal of Occupational Therapy,* 17**,** 221-225.

AYRES, A. 1972. Sensory integration and learning disabilities. *Western Psychological Services. Los Angeles*.

AYRES, A. J. 1964. Tactile functions: Their relation to hyperactive and perceptual motor behavior. *American Journal of Occupational Therapy,* 18**,** 6-11.

AYRES, A. J. 1965. Patterns of perceptual-motor dysfunction in children: A factor analytic study. *Perceptual and Motor Skills,* 20**,** 335-368.

BAILEY, D. M. 1997. *Research for the Health Professional - A Practical Guide.,* Philadelphia, F.A. Davis Company.

BAKER, A. E., LANE, A., ANGLEY, M. T. & YOUNG, R. L. 2008. The relationship between sensory processing patterns and behavioural responsiveness in autistic disorder: A pilot study. *Journal of Autism and Developmental Disorders,* 38**,** 867-875.

BAR-SHALITA, T., VATINE, J. J. & PARUSH, S. 2008. Sensory modulation disorder: a risk factor for participation in daily life activities. *Developmental Medicine & Child Neurology,* 50**,** 932-937.

BARANEK, G. T. 2002. Efficacy of sensory and motor interventions for children with autism. *Journal of autism and developmental disorders,* 32**,** 397-422.

BARANEK, G. T., DAVID, F. J., POE, M. D., STONE, W. L. & WATSON, L. R. 2006. Sensory Experiences Questionnaire: Discriminating sensory features in young children with autism, developmental delays, and typical development. *Journal of Child Psychology and Psychiatry,* 47**,** 591-601.

BEAR, M., CONNORS, B. & PARADISO, M. 1996. Chemical control of the brain and behavior. *Neuroscience Exploring the Brain. New York: Williams and Wilkins***,** 402-32.

BEN-SASSON, A., CARTER, A. & BRIGGS-GOWAN, M. 2009. Sensory over-responsivity in elementary school: prevalence and social-emotional correlates. *Journal of abnormal child psychology,* 37**,** 705-716.

BENSON, J. D., BEEMAN, E., SMITSKY, D. & PROVIDENT, I. 2011. The Deep Pressure and Proprioceptive Technique (DPPT) Versus Nonspecific Child-Guided Brushing: A Case Study. *Journal of Occupational Therapy, Schools & Early Intervention,* 4**,** 204-214.

BHOPTI, A. 2011. Examining the Wilbarger's deep pressure and proprioceptive technique for treating children with sensory defensiveness using a multiple single case study approach. Occupational Therapy Australia, 24th National Conference and Exhibition, 29 June - 1 July 2011. *Australian Occupational Therapy Journal,* 58**,** 134-134.

BRETT-GREEN, B. A., MILLER, L. J., SCHOEN, S. A. & NIELSEN, D. M. 2010. An exploratory event-related potential study of multisensory integration in sensory over-responsive children. *Brain Research,* 1321**,** 67-77.

BRÖRING, T., ROMMELSE, N., SERGEANT, J. & SCHERDER, E. 2008. Sex differences in tactile defensiveness in children with ADHD and their siblings. *Developmental Medicine & Child Neurology,* 50**,** 129-133.

BUNDY, A. C., LANE, S. J., MURRAY, E. A. & FISHER, A. G. 2002. *Sensory integration: Theory and practice*, F.A. Davis Philadelphia.

CHAPPARO, C. & MORA, L. 2008. *The impact of the Sensory Protocol on functional behavioural responses of children with intellectual disability, sensory defensiveness and behaviour support needs* [Online]. Available: http://www.asid.asn.au/Portals/0/Conferences/43rd%20Melbourne/Mora%20Impact%20of%20the%20Sensory%20Protocol.pdf [Accessed 29 April 2013].

CHAPPARO, C. & MORA, L. 2011. Use of a sensory protocol by parents of children with intellectual disability and sensory defensiveness to achieve functional and behavioural goals: a randomised controlled study. Occupational Therapy Australia, 24th National Conference and Exhibition, 29 June - 1 July 2011. *Australian Occupational Therapy Journal,* 58**,** 59-59.

CHENG, M. & BOGGETT-CARSJENS, J. 2005. Consider sensory processing disorders in the explosive child: Case report and review. *The Canadian child and adolescent psychiatry review,* 14**,** 44.

CLARK, G. F. & WARD, S. 1999. Charting results: evaluating progress of children with sensory processing disorder. *OT Practice,* 4**,** 12-16.

CLOW, A., HUCKLEBRIDGE, F. & THORN, L. 2010. The cortisol awakening response in context. *International review of neurobiology,* 93**,** 153-175.

COHN, E., MILLER, L. J. & TICKLE-DEGNEN, L. 2000. Parental hopes for therapy outcomes: Children with sensory modulation disorders. *The American Journal of Occupational Therapy,* 54**,** 36-43.

COHN, E. S. 2001. Parent perspectives of occupational therapy using a sensory integration approach. *American Journal of Occupational Therapy,* 55**,** 285-294.

DAVIES, P. L. & GAVIN, W. J. 2007. Validating the diagnosis of sensory processing disorders using EEG technology. *American Journal of Occupational Therapy,* 61**,** 176-189.

DAVIS, T. N., DURAND, S. & CHAN, J. M. 2011. The Effects of a Brushing Procedure on Stereotypical Behavior. *Research in Autism Spectrum Disorders,* 5**,** 1053-1058.

DE HAAN, M., GUNNAR, M. R., TOUT, K., HART, J. & STANSBURY, K. 1998. Familiar and novel contexts yield different associations between cortisol and behavior among 2-year-old children. *Developmental Psychobiology,* 33**,** 93-101.

DEMOPOULOS, M. 2009. *A pilot study of the effect of a sensory diet on the in-seat behaviour of grade one learners in the classroom.*

DINARDO, J. 2008. *Natural experiments and quasi-natural experiments*.

DUNN, W. 1997. The impact of sensory processing abilities on the daily lives of young children and their families: A conceptual model. *Infants & Young Children,* 9**,** 23-35.

DUNN, W. 1999. *The Sensory Profile: User's Manual,* San Antonio, TX: Therapy Skill Builders.

DUNN, W. 2007. Supporting children to participate successfully in everyday life by using sensory processing knowledge. *Infants & Young Children: An Interdisciplinary Journal of Special Care Practices,* 20**,** 84-101.

DUNN, W. & BROWN, C. 1997. Factor analysis on the Sensory Profile from a national sample of children without disabilities. *The American Journal of Occupational Therapy,* 51**,** 490-495.

EDWARDS, R. 1986. Assessing the social behaviour of the learning disabled child in the classroom. . *The South African Journal of Occupational Therapy***,** 23-29.

EDWARDS, S., CLOW, A., EVANS, P. & HUCKLEBRIDGE, F. 2001. Exploration of the awakening cortisol response in relation to diurnal cortisol secretory activity. *Life sciences,* 68**,** 2093-2103.

FERTEL-DALY, D., BEDELL, G. & HINOJOSA, J. 2001. Effects of a weighted vest on attention to task and self-stimulatory behaviors in preschoolers with pervasive developmental disorders. *American Journal of Occupational Therapy,* 55**,** 629-640.

FIELD, T. M. 1998. Massage therapy effects. *American Psychologist,* 53**,** 1270.

FISHER, A. & DUNN, W. 1983. Tactile defensiveness: historical perspectives, new research - a theory grows. *Sensory Integration Special Interest Section Newsletter,* 6**,** 1-2.

FOSS, A., SWINTH, Y., MCGRUDER, J. & TOMLIN, G. 2003. Sensory modulation dysfunction and the Wilbarger Protocol: an evidence review. *OT Practice,* 8**,** 1-8.

GOLDSMITH, H., VAN HULLE, C. A., ARNESON, C., SCHREIBER, J. & GERNSBACHER, M. 2006. A population-based twin study of parentally reported tactile and auditory defensiveness in young children. *Journal of abnormal child psychology,* 34**,** 378-392.

HANRAHAN, K., MCCARTHY, A. M., KLEIBER, C., LUTGENDORF, S. & TSALIKIAN, E. 2006. Strategies for salivary cortisol collection and analysis in research with children. *Applied Nursing Research,* 19**,** 95-101.

HILTON, C., GRAVER, K. & LAVESSER, P. 2007. Relationship between Social Competence and Sensory Processing in Children with High Functioning Autism Spectrum Disorders. *Research in Autism Spectrum Disorders,* 1**,** 164-173.

INTERDISCIPLINARY COUNCIL ON DEVELOPMENTAL AND LEARNING DISORDERS 2005. Diagnostic manual for infancy and early childhood: Mental health, developmental and regulatory sensory processing and language disorders and learning challenges (ICDL-DMIC). Bethesda.

JACOBSON, N. S. & TRUAX, P. 1991. Clinical significance: a statistical approach to defining meaningful change in psychotherapy research. *Journal of consulting and clinical psychology,* 59**,** 12.

JAMES, K., MILLER, L. J., SCHAAF, R., NIELSEN, D. M. & SCHOEN, S. A. 2011. Phenotypes within sensory modulation dysfunction. *Comprehensive Psychiatry,* 52**,** 715-724.

KANDEL, E. R., SCHWARTZ, J. H. & JESSELL, T. M. 2000. *Principles of neural science*, McGraw-Hill New York.

KIELHOFNER, G. 2006. *Research in occupational therapy: Methods of inquiry for enhancing practice*, F.A. Davis Company.

KIMBALL, J. G., LYNCH, K. M., STEWART, K. C., WILLIAMS, N. E., THOMAS, M. A. & ATWOOD, K. D. 2007. Using salivary cortisol to measure the effects of a Wilbarger protocol-based procedure on sympathetic arousal: a pilot study. *American Journal of Occupational Therapy,* 61**,** 406-413.

KINNEALEY, M. 1998. Princess or tyrant: a case report of a child with sensory defensiveness. *Occupational Therapy International,* 5**,** 293-303.

KINNEALEY, M. & FUIEK, M. 1999. The relationship between sensory defensiveness, anxiety, depression and perception of pain in adults. *Occupational Therapy International,* 6**,** 195-206.

KINNEALEY, M., OLIVER, B. & WILBARGER, P. 1995. A phenomenological study of sensory defensiveness in adults. *American Journal of Occupational Therapy,* 49**,** 444-451.

KOENIG, K. P. & RUDNEY, S. G. 2010. Performance Challenges for Children and Adolescents With Difficulty Processing and Integrating Sensory Information: A Systematic Review. *American Journal of Occupational Therapy,* 64**,** 430-442.

LANE, S. 2002a. Sensory modulation. *In:* BUNDY, A. C., LANE, S. J. & MURRAY, E. A. (eds.) *Sensory integration: Theory and practice.* 2nd ed. Philadelphia: F.A. Davis.

LANE, S. J. 2002b. Structure and function of the sensory systems. *In:* BUNDY, A. C., LANE, S. J. & MURRAY, E. A. (eds.) *Sensory integration: Theory and practice.* 2nd ed. Philadelphia: F.A. Davis.

LANE, S. J., MILLER, L. J. & HANFT, B. E. 2000. Toward a consensus in terminology in sensory integration theory and practice: part 2: sensory integration patterns of function and dysfunction. *Sensory Integration Special Interest Section Quarterly,* 23**,** 1-3.

LANE, S. J., REYNOLDS, S. & THACKER, L. 2010. Sensory over-responsivity and ADHD: Differentiating using electrodermal responses, cortisol, and anxiety. *Frontiers in Integrative Neuroscience,* 4.

LANE, S. J. & SCHAAF, R. C. 2010. Examining the neuroscience evidence for sensory-driven neuroplasticity: implications for sensory-based occupational therapy for children and adolescents. *American Journal of Occupational Therapy,* 64**,** 375-390.

LEDOUX, J. E. 2003. *Synaptic self: How our brains become who we are*, Penguin.

LEVY, F. 2004. Synaptic gating and ADHD: a biological theory of comorbidity of ADHD and anxiety. *Neuropsychopharmacology,* 29**,** 1589-1596.

LUMLEY, M. A., SCHRAMM, W., POMERLEAU, C. S., POMERLEAU, O. F. & SMITH, R. H. 1995. The assessment of cortisol using salivary ultrafiltrate. *Behavior Research Methods, Instruments, & Computers,* 27**,** 470-475.

MAILLOUX, Z. & BURKE, J. P. 1997. Play and the sensory integrative approach. *In:* PARHAM, L. D. & FAZIO, L. S. (eds.). St Louis: MO: Mosby-Year Book, Inc.

MAILLOUX, Z., MAY-BENSON, T. A., SUMMERS, C. A., MILLER, L. J., BRETT-GREEN, B., BURKE, J. P., COHN, E. S., KOOMAR, J. A., PARHAM, L. D., ROLEY, S. S., SCHAAF, R. C. & SCHOEN, S. A. 2007. Goal attainment scaling as a measure of meaningful outcomes for children with sensory integration disorders. *American Journal of Occupational Therapy,* 61**,** 254-259.

MANGEOT, S. D., MILLER, L. J., MCINTOSH, D. N., MCGRATH-CLARKE, J., SIMON, J., HAGERMAN, R. J. & GOLDSON, E. 2001. Sensory modulation dysfunction in children with attention-deficit–hyperactivity disorder. *Developmental Medicine & Child Neurology,* 43**,** 399-406.

MAY-BENSON, T. A. & KOOMAR, J. A. 2010. Systematic review of the research evidence examining the effectiveness of interventions using a sensory integrative approach for children. *The American Journal of Occupational Therapy,* 64**,** 403-414.

MCINTOSH, D. N., MILLER, L. J., SHYU, V. & DUNN, W. 1999a. Overview of the Short Sensory Profile (SSP). *In:* DUNN, W. (ed.) *The Sensory Profile: Examiner's manual.* San Antonio, TX: The Psychological Corporation.

MCINTOSH, D. N., MILLER, L. J., SHYU, V. & HAGERMAN, R. J. 1999. Sensory-modulation disruption, electrodermal responses, and functional behaviors. *Developmental Medicine & Child Neurology,* 41**,** 608-615.

MELZACK, R. Gate control theory: On the evolution of pain concepts. Pain forum, 1996. Elsevier, 128-138.

MILLER, G. E., CHEN, E. & ZHOU, E. S. 2007a. If it goes up, must it come down? Chronic stress and the hypothalamic-pituitary-adrenocortical axis in humans. *Psychological bulletin,* 133**,** 25.

MILLER, L. 2003a. Empirical evidence related to therapies for sensory processing impairments. *NASP Communique,* 31**,** 34-37.

MILLER, L. J. 2003b. Empirical evidence related to therapies for sensory processing impairments. *NASP Communique,* 31**,** 34-37.

MILLER, L. J., ANZALONE, M. E., LANE, S. J., CERMAK, S. A. & OSTEN, E. T. 2007b. Concept evolution in sensory integration: a proposed nosology for diagnosis. *American Journal of Occupational Therapy,* 61**,** 135-140.

MILLER, L. J., ANZALONE, M. E., LANE, S. J., CERMAK, S. A. & OSTEN, E. T. 2007c. Concept evolution in sensory integration: a proposed nosology for diagnosis. *American Journal of Occupational Therapy,* 61**,** 135-140.

MILLER, L. J., COLL, J. R. & SCHOEN, S. A. 2007d. A randomized controlled pilot study of the effectiveness of occupational therapy for children with sensory modulation disorder. *American Journal of Occupational Therapy,* 61**,** 228-238.

MILLER, L. J., COLL, J. R. & SCHOEN, S. A. 2007e. A randomized controlled pilot study of the effectiveness of occupational therapy for children with sensory modulation disorder. *The American Journal of Occupational Therapy,* 61**,** 228-238.

MILLER, L. J., NIELSEN, D. M. & SCHOEN, S. A. 2012. Attention deficit hyperactivity disorder and sensory modulation disorder: A comparison of behavior and physiology. *Research in developmental disabilities,* 33**,** 804-818.

MILLER, L. J., REISMAN, J., MACINTOSH, S. N. & SIMON, J. 2001. An ecological model of sensory modulation: performance of children with fragile X syndrome, autism, attention-deficit/hyperactivity disorder, and sensory modulation dysfunction. *In:* ROLEY, S., SCHAAF, R. & BLANCHE, E. (eds.) *The nature of sensory integration with diverse populations.* San Antonio: TX: Therapy Skill Builders.

MILLER, L. J., SCHOEN, S. A., JAMES, K. & SCHAAF, R. C. 2007f. Lessons learned: A pilot study of occupational therapy effectiveness for children with sensory modulation disorder. *American Journal of Occupational Therapy,* 61**,** 161.

MORRIS, J. G., GRATTAN-SMITH, P., JANKELOWITZ, S. K., FUNG, V. S., CLOUSTON, P. D. & HAYES, M. W. 2002. Athetosis II: the syndrome of mild athetoid cerebral palsy. *Movement disorders,* 17**,** 1281-1287.

MULLIGAN, S. 1996. An analysis of score patterns of children with attention disorders on the Sensory Integration and Praxis Tests. *American Journal of Occupational Therapy,* 50**,** 647-654.

NATIONAL HEALTH AND MEDICAL RESEARCH COUNCIL. 2009. *NHMRC levles of evidence and grades for recommendations for developers of guidelines* [Online]. Available: http://www.nhmrc.gov.au/_files_nhmrc/file/guidelines/evidence_statement_form.pdf. [Accessed 29 April 2013].

NEAL, J. A., EDELMANN, R. J. & GLACHAN, M. 2002. Behavioural inhibition and symptoms of anxiety and depression: Is there a specific relationship with social phobia? *British Journal of Clinical Psychology,* 41**,** 361-374.

NIGG, J. T. 2006. Temperament and developmental psychopathology. *Journal of Child Psychology and Psychiatry,* 47**,** 395-422.

PARHAM, D. & MAILLOUX, Z. 2001. Sensory Integration. *In:* CASE-SMITH (ed.) *Occupational Therapy for Children.* 4th ed. Missouri: Mosby.

PARHAM, L. D. 1998. The relationship of sensory integrative development to achievement in elementary students: four-year longitudinal patterns. *Occupational Therapy Journal of Research,* 18**,** 105-127.

PARHAM, L. D., ROLEY, S. S., MAY-BENSON, T. A., KOOMAR, J., BRETT-GREEN, B., BURKE, J. P., COHN, E. S., MAILLOUX, Z., MILLER, L. J. & SCHAAF, R. C. 2011. Development of a fidelity measure for research on the effectiveness of the Ayres Sensory Integration® intervention. *American Journal of Occupational Therapy,* 65**,** 133-142.

PAUL, S., SINEN, P., JOHNSON, J., LATSHAW, C., NEWTON, J., NELSON, A. & POWERS, R. 2003. The effects of a sensory motor activities protocol based on the theory of sensory integration on children diagnosed with preprimary impairments. *Occupational Therapy in Health Care,* 17**,** 19-34.

PDM TASK FORCE 2006. Psychodynamic diagnostic manual. Silver Spring, MD: Alliance of Psychoanalytic Organizations.

PERT, C. B. 1997. *Molecules of emotion: Why you feel the way you feel*, Simon and Schuster.

PFEIFFER, B., KINNEALEY, M., REED, C. & HERZBERG, G. 2005. Sensory modulation and affective disorders in children and adolescents with Asperger's disorder. *The American Journal of Occupational Therapy,* 59**,** 335-345.

REYNOLDS, S. & LANE, S. J. 2008. Diagnostic validity of sensory over-responsivity: A review of the literature and case reports. *Journal of Autism and Developmental Disorders,* 38**,** 516-529.

REYNOLDS, S., LANE, S. J. & GENNINGS, C. 2010. The Moderating Role of Sensory Overresponsivity in HPA Activity: A Pilot Study With Children Diagnosed With ADHD. *Journal of Attention Disorders,* 13**,** 468-478.

ROGERS, S. J., HEPBURN, S. & WEHNER, E. 2003. Parent reports of sensory symptoms in toddlers with autism and those with other developmental disorders. *Journal of autism and developmental disorders,* 33**,** 631-642.

ROGERS, S. J. & OZONOFF, S. 2005. Annotation: What do we know about sensory dysfunction in autism? A critical review of the empirical evidence. *Journal of Child Psychology and Psychiatry,* 46**,** 1255-1268.

ROLEY, S. & WILBARGER, J. 1994. What is sensory integration? *A series of interviews on the scope, limitations, and evolution of sensory integration theory. Sensory Integration Special Interest Section Newsletter,* 17**,** 1-7.

SALIMETRICS 2012. High and Low Salivary Cortisol Control Ranges. High Sensitivity Salivary Cortisol EIA Kit Pennsylvania, USA: Salimetrics.

SALIMETRICS 2014. Expanded Range High Sensitivity Salivary Cortisol Enzyme Immunoassay Kit.

SCHAAF, R. C., BENEVIDES, T., BLANCHE, E. I., BRETT-GREEN, B. A., BURKE, J. P., COHN, E. S., KOOMAR, J., LANE, S. J., MILLER, L. J., MAY-BENSON, T. A., PARHAM, D., REYNOLDS, S. & SCHOEN, S. A. 2010a. Parasympathetic functions in children with sensory processing disorder. *Frontiers in Integrative Neuroscience,* 4.

SCHAAF, R. C. & MILLER, L. J. 2005. Novel therapies for developmental disabilities occupational therapy using a sensory integrative approach. *Journal of Mental Retardation and Developmental Disabilities,* 11**,** 143-148.

SCHAAF, R. C., MILLER, L. J., SEAWELL, D. & O'KEEFE, S. 2003. Children with disturbances in sensory processing: a pilot study examining the role of the parasympathetic nervous system. *The American Journal Of Occupational Therapy: Official Publication Of The American Occupational Therapy Association,* 57**,** 442-449.

SCHAAF, R. C. & NIGHTLINGER, K. M. 2007. Occupational therapy using a sensory integrative approach: a case study of effectiveness. *The American Journal Of Occupational Therapy: Official Publication Of The American Occupational Therapy Association,* 61**,** 239-246.

SCHAAF, R. C., SCHOEN, S. A., SMITH ROLEY, S., LANE, S. J., KOOMAR, J. A. & MAY-BENSON, T. A. 2010b. A Frame of Reference for Sensory Integration. *In:* KRAMER, P. & HINOJOSA, J. (eds.) *Frames of Reference for Pediatric Occupational Therapy.* 3rd ed. Baltimore: Lippincott Williams & Wilkins.

SCHAAF, R. C. & SMITH ROLEY, S. 2006. *SI: Applying clinical reasoning to diverse populations,* San Antonio, TX: Psychological Corporations

SCHAFFER, R., LAW, M., POLATAJKO, H. & MILLER, J. 1989. A Study of Children with Learning Disablities and Sensorimotor Problems or Let's Not Throw the Baby Out with the Bathwater. *Physical & occupational therapy in pediatrics,* 9**,** 101-117.

SCHMIDT, N. A. 1997. Salivary cortisol testing in children. *Issues in comprehensive pediatric nursing,* 20**,** 183-190.

SCHOEN, S. A., MILLER, L. J., BRETT-GREEN, B. A. & NIELSEN, D. M. 2009. Physiological and behavioral differences in sensory processing: A comparison of children with autism spectrum disorder and sensory modulation disorder. *Frontiers in Integrative Neuroscience,* 3.

SCHOEN, S. A., MILLER, L. J. & GREEN, K. E. 2008. Pilot study of the Sensory Over-Responsivity Scales: assessment and inventory. *American Journal of Occupational Therapy,* 62**,** 393-406.

SCHULZ, K. P., HALPERIN, J. M., NEWCORN, J. H., SHARMA, V. & GABRIEL, S. 1997. Plasma cortisol and aggression in boys with ADHD. *Journal of the American Academy of Child & Adolescent Psychiatry,* 36**,** 605-609.

SEGAL, R. & BEYER, C. 2006. Integration and application of a home treatment program: a study of parents and occupational therapists. *American Journal of Occupational Therapy,* 60**,** 500-510.

STAGNITTI, K., RAISON, P. & RYAN, P. 1999. Sensory defensiveness syndrome: A paediatric perspective and case study. *Australian Occupational Therapy Journal,* 46**,** 175-187.

STALKER, A. & REEBYE, P. 2007. *Understanding regulation disorders of sensory processing in children: Management strategies for parents and professionals*, Jessica Kingsley Publishers.

SUDORE, K. 2001. Tactile Defensiveness and the Wilbarger brushing protocol in system management, [Unpublished master's thesis] Buffalo, New York: D'Youville College.

TAYLOR, M. C. 2000. *Evidence-based practice for occupational therapists,* London, Blackwell Science

TICKLE-DEGNEN, L. 2000. Evidence-based practice forum. What is the best evidence to use in practice? *American Journal of Occupational Therapy,* 54**,** 218-221.

TOMCHEK, S. D. & DUNN, W. 2007. Sensory processing in children with and without autism: a comparative study using the short sensory profile. *The American Journal of Occupational Therapy,* 61**,** 190-200.

VANDENBERG, N. L. 2001. The use of a weighted vest to increase on-task behavior in children with attention difficulties. *American Journal of Occupational Therapy,* 55**,** 621-628.

VENABLES, P. H. & CHRISTIE, M. J. 1980. Electrodermal activity. *Techniques in psychophysiology,* 54**,** 3.

WEEKS, S., BOSHOFF, K. & STEWART, H. 2012. Systematic review of the effectiveness of the Wilbarger protocol with children. *Pediatric Health, Medicine and Therapeutics,* 3**,** 79-89.

WILBARGER, P. 1995. The sensory diet: Activity programs based on sensory processing theory. *Sensory Integration Special Interest Section Newsletter,* 18**,** 1-4.

WILBARGER, P. & WILBARGER, J. 1991. *Sensory Defensiveness in children aged 2-12: An intervention guide for parents and other caretakers,* Santa Barbara, CA: Avanti Educational Progams.

WILBARGER, P. & WILBARGER, J. 2012a. *Sensory Defensiveness: A Comprehensive Treatment Approach* Panorama City, CA, Avanti Educational Programs.

WILBARGER, P. & WILBARGER, J. 2012b. *Sensory Defensiveness: A Comprehensive Treatment Approach*. Avanti Educational Programs, Inc.: Santa Barbara, CA.

WORLD HEALTH ORGANISATION, W. H. O. 2007. *International Classification of Functioning, Disability, and Health: Children & Youth Version: ICF-CY*, World Health Organisation.

ZBYTNIEWSKI, R. 2002. *The Effects of Sensory Integration's Wilbarger Technique on Engaging Behaviors [Master's thesis].* Touro College.

ZERO TO THREE 2005. Diagnostic classification of mental health and developmental disorders of infancy and childhood, revised (DC:0-3R). Arlington, VA: National Center for Clinical Infant Programs.

ZUCKERMAN, M. 1979. *Sensation seeking*, Wiley Online Library.

APPENDIX A

Human Research Ethics Committee – Permission granted

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Ms Genna Irving

CLEARANCE CERTIFICATE	**M120676**
PROJECT	The Short Term effects of a Wallbarger Protocol-Based Procedue on Behavioural Modulation and Sympethetic Arousal in Children Aged 4-8Years with Sensory Processing Difficulties
INVESTIGATORS	Ms Genna Irving.
DEPARTMENT	Department of Occupational Therapy
DATE CONSIDERED	29/06/2012
DECISION OF THE COMMITTEE*	Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE 22/08/2012 **CHAIRPERSON** .....
(Professor PE Cleaton-Jones)

*Guidelines for written 'informed consent' attached where applicable
cc: Supervisor : Mrs Denise Franszen

DECLARATION OF INVESTIGATOR(S)
To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES...

APPENDIX BI

HeronBridge
COLLEGE
Educating young South Africans with Heart

Postnet Suite 707
Private Bag X153
Bryanston
2021

Tel: +2711 540 4800
Fax: +2711 388 1948
Cell: +27 82 771 4470

e-mail: admin@heronbridge.co.za
www.heronbridgecollege.co.za

August 2012

Dear Ms Irving

HeronBridge Preparatory grant you the permission to recruit pupils from Grade One to Grade Three and to use children currently being seen by our Occupational Therapists in the on-site therapy centres, for the following research:

"The short-term effects of a Wilbarger Deep Tactile and Proprioceptive Technique (DTPT) on behavioural modulation and sympathetic arousal in children aged 4-8 years with sensory processing difficulties."

We are aware of the ethical procedures outlined for this research and we ask that you adhere to these throughout the study for the protection of our therapists and parents.

Yours sincerely

L Bartlet (Mrs)
Preparatory Deputy Head

Reg. No. 2001/014539/08
Association incorporated under Section 21
Directors: R G Caw TTHD, Associated Valuer, J C Fellingham CA(SA), T J Irving TTHD, A G Tomlinson BCompt, D G Tomlinson CA(SA) (Managing)

APPENDIX BII

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Cell: +27 82 771 4470

e-mail: admin@heronbridge.co.za
www.heronbridgecollege.co.za

August, 2012

Dear Ms Irving

HeronBridge Pre-Preparatory grant you the permission to recruit learners from our school who are currently on our Occupational Therapy caseload and seen on-site in our therapy centre, for the purpose of following research:

"The short-term effects of a Wilbarger Deep Tactile and Proprioceptive Technique (DTPT) on behavioral modulation and sympathetic arousal in children aged 4-8 years with sensory processing difficulties."

We are aware of the ethical procedures outlined for this research and we ask that you adhere to these throughout the study for the protection of our therapists and parents.

Yours sincerely

G Courtney (Mrs)
Pre-Preparatory Head

Reg. No. 2001/014539/08
Association incorporated under Section 21
Directors: R G Caw TTHD, Associated Valuer, J C Fellingham CA(SA), T J Irving TTHD, A G Tomlinson BCompt, D G Tomlinson CA(SA) (Managing)

ACSI ISASA

APPENDIX BIII

Land of Oz

Fourways:
32 Swallow Drive, Norscot Slopes
Tel : 011 027 5010
Email : fourways@landofoz.co.za

Chartwell:
119 Third Road, Chartwell
Tel : 011 023 5010
Email : chartwell@landofoz.co.za

August 2012

Dear Ms. G Irving

This letter serves to inform you that **Land of Oz Nursery schools** hereby grants you permission to recruit pupils from both the Fourways and Broadacres on-site therapy centres for the following research:

"The short-term effects of a Wilbarger Deep Tactile and Proprioceptive Technique (DTPT) on behavioural modulation and sympathetic arousal in children aged 4-8 years with sensory processing difficulties."

We are aware of the ethical procedures outlined for this research and we ask that you adhere to these throughout the study for the protection of our therapists and parents.

Kind Regards

Hart.

Portia Hart

Head of Department

APPENDIX BIV

Occupational Therapy

School of Therapeutic Sciences • Faculty of Health Sciences • 7 York Road, Parktown 2192, South Africa
Tel: +27 11 717-3701 • Fax: +27 11 717-3709 • E-mail: denise.franzsen@wits.ac.za

Permission for the study.

The Principal, _____ School,

Dear Sir/Madam,

I, Genna Irving, am an occupational therapist currently completing my Master's degree at the University of the Witwatersrand. I am conducting research investigating, "The short-term effects of a Wilbarger Deep Tactile and Proprioceptive Technique (DTPT) on behavioural modulation and sympathetic arousal in children aged 4-8 years with sensory processing difficulties."

I would like to invite learners at your school who are currently being seen for treatment in occupational therapy to consider participating in this study with their parent's consent. I want to request your permission to include your learners in the research and conduct this study on your school premises in the therapy centre on-site, immediately after a school day.

The research investigating the effectiveness of this procedure will be two-fold. The study aims to measure changes in behavioural modulation before and after administrating the Wilbarger DTPT by determining the immediate change in behavioural responsiveness in children with sensory processing difficulties, using video recording. The study will further investigate if there are short-term changes in sympathetic arousal following a single application of the Wilbarger DTPT to children overresponsive to sensory stimuli by measuring the change in salivary cortisol levels.

The data will be collected in one session of 45 minutes during which all participants will be engaged in an Activity protocol for 15 minutes before and after the intervention is administered. The Wilbarger DTPT will be applied to each participant following the initial 15-minute Activity protocol (pre-test). In determining the data,

two collections of saliva from each child as a pre-and post-test measurement and video recordings of all participants' behaviour while engaging in the Activity protocol (different table-top activities, i.e., puzzles, blocks, colouring), will be taken before and after exposure to the intervention.

I wish to recruit a sample of five/six children from your school to take part in this study, if your permission is granted. The procedures will incur no cost to the parents or to the school.

Please note that stringent steps will be taken to ensure ethically correct procedures in video recording and obtaining saliva samples, according to bioethical and HPCSA stipulations. Specifically, this will ensure that videotapes and salivary cortisol samples will be stored together at the University of the Witwatersrand to which only the researcher will have access. Analysis of the saliva samples will be carried out on these premises by the researcher and one physiologist assistant. A selected observer, one other occupational therapist qualified in sensory integration, will analyse the videos with the researcher.

The parents and participants will be given pertinent information on all aspects of the study prior to giving consent/assent in an information sheet, and feedback related to the findings of the study will be available on request. Confidentiality will be ensured throughout the research process, as no names will be used in the data collection process and all videos and samples collected will be available to the researcher and her assistants only and will be destroyed six years after analysis or following publication of the study. Participation will be voluntary and participants may withdraw or be withdrawn by their parents at any point without consequence. Although no direct benefit can be expected for each participant receiving the intervention only once in the study, previous exposure of participants to the Wilbarger DTPT means that the intervention will be familiar to each child when administered. Thus, no risks are expected for the child.

This study aims to provide evidence for Ayres-SI techniques, and occupational therapists with more scientifically rigorous results to determine the effectiveness of the Wilbarger DTPT, widely used in the treatment of children with sensory processing difficulties.

If you have any further questions please do not hesitate to contact me on 082 452 7212. For any concerns about the ethics of this study you may contact Prof P Cleaton-Jones, the chairman of the Human Research Ethics Committee at 011 717 1234 or anisa.keshav@wits.ac.za,

Regards,

_____

Genna Irving

B.Sc(OT)UCT

APPENDIX CI

BRONWYN NOYLE
and Associates

Occupational Therapist BSc OT (Wits)
Pr No: 0361402 **HPCSA No:** 0073849

Land of Oz:
Family Centre at Fourways
32 Swallow Drive
119 3rd Road Chartwell

Email: bron.noyle@gmail.com
Cell: 071 352 4257

August 2012

Dear Ms. G Irving

The Occupational Therapists working in the on-site therapy centres at Land of Oz Nursery schools give you permission to recruit children from the current treatment caseload who have been receiving the Wilbarger DTPT, for the purpose of the following research:

"The short-term effects of a Wilbarger Deep Tactile and Proprioceptive Technique (DTPT) on behavioural modulation and sympathetic arousal in children aged 4-8 years with sensory processing difficulties."

We are happy to assist in issuing and obtaining consent forms, demographical questionnaires and other necessary parent-report scales, including the child's Sensory Profiles, to be used in this study once consent has been obtained from the parents.

Kind Regards

Bronwyn Noyle

Occupational Therapist

APPENDIX CII

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www.heronbridgecollege.co.za

August 2012

Dear Ms Irving

The Occupational Therapists working in the on-site therapy centre at HeronBridge College grant you permission to recruit children from the current treatment caseload who have been receiving the Wilbarger DTPT, for the purpose of the following research:

"The short-term effects of a Wilbarger Deep Tactile and Proprioceptive Technique (DTPT) on behavioural modulation and sympathetic arousal in children aged 4-8 years with sensory processing difficulties."

We are happy to assist in issuing and obtaining consent forms, demographical questionnaires and other necessary parent-report scales, including the child's Sensory Profiles, to be used in this study once consent has been obtained from the parents.

Yours sincerely

S van der Merwe (Mrs)
Occupational Therapist

Reg. No. 2001/014539/08
Association Incorporated under Section 21
Directors: R G Caw TTHD, Associated Valuer, J C Fellingham CA(SA), T J Irving TTHD, A G Tomlinson BCompt, D G Tomlinson CA(SA) (Managing)

APPENDIX CIII

Information Sheet - Occupational Therapists

Dear Colleague,

I, Genna Irving, am an occupational therapist currently completing my Master's degree at the University of the Witwatersrand. I am conducting research investigating, "The short-term effects of a Wilbarger Deep Tactile and Proprioceptive Technique (DTPT) on behavioural modulation and sympathetic arousal in children aged 4-8 years with sensory processing difficulties".

I would like to invite learners from the school at which you provide occupational therapy and who are currently being seen for treatment to participate in my research study. I want to request, specifically, your approval to include children from your treatment caseload who have been receiving the Wilbarger DTPT. The study will be conducted on the school premises in the therapy centre on-site, immediately after a school day. Please note that refusal to participate will not compromise the child or their therapy in any way.

The study aims to measure changes in behavioural modulation before and after administrating the Wilbarger DTPT by determining the immediate change in behavioural responsiveness in children. The study will further investigate if there are short-term changes in sympathetic arousal following a single application of the Wilbarger DTPT by measuring the change in salivary cortisol levels.

The data will be collected in one session of 45 minutes during which all participants will be engaged in an Activity protocol for 15 minutes before and after the intervention is administered. The Wilbarger DTPT will be applied to each participant following the initial 15-minute Activity protocol (pre-test). In determining the data, two collections of saliva from each child as a pre-and post-test measurement and video recordings of all participants' behaviour while engaging in the Activity protocol (different table-top activities, i.e., puzzles, blocks, colouring), will be taken before and after exposure to the intervention.

I wish to recruit a sample of five/six children from your school to take part in this study, if your permission is granted. The procedures will incur no cost to the parents or to the school.

I would need your assistance in issuing and obtaining consent forms, demographical questionnaires and other necessary parent-report scales, specifically the child's Sensory Profiles, to be used in this study. These would need to be collected from the parent or legal guardian of participants if consent from the parents for their child to participate in the research is granted. I, however, will make telephonic contact with the parents regarding these forms, prior to the forms being sent home. I will answer any questions thereafter.

Please note that stringent steps will be taken to ensure ethically correct procedures in video recording and obtaining saliva samples, according to bioethical and HPCSA stipulations. Specifically, this will ensure that videotapes and salivary cortisol samples will be stored together at the University of the Witwatersrand to which only the researcher will have access. Analysis of the saliva samples will be carried out on these premises by the researcher and one physiologist assistant. A selected observer, one other occupational therapist qualified in sensory integration, will analyse the videos with the researcher.

The parents and participants will be given pertinent information on all aspects of the study prior to giving consent/assent in an information sheet, and feedback related to the findings of the study will be available on request. Confidentiality will be ensured throughout the research process, as no names will be used in the data collection process and all videos and samples collected will be available to the researcher and her assistants only and will be destroyed six years after analysis or following publication of the study. Participation will be voluntary and participants may withdraw or be withdrawn by their parents at any point without consequence. Although no direct benefit can be expected for each participant receiving the intervention only once in the study, previous exposure of participants to the Wilbarger DTPT means that the intervention will be familiar to each child when administered. Thus, no risks are expected for the child.

This study aims to provide evidence for Ayres-SI techniques, and occupational therapists with more scientifically rigorous results to determine the effectiveness of the Wilbarger DTPT, widely used by the profession in the treatment of children with sensory processing difficulties.

If you have any further questions please do not hesitate to contact me on 082 452 7212.

If you have any concerns about the ethics of the study you may contact Prof P Cleaton-Jones, the chairman of the Human Research Ethics Committee at 011 717 1234 or anisa.keshav@wits.ac.za.

Regards,

_____

G. Irving

B.Sc(OT)UCT

APPENDIX D

Information sheet – Parents/Legal Guardian

Dear Parents,

I, Genna Irving, am an occupational therapist currently completing my Master's degree at the University of the Witwatersrand. I am conducting research investigating, "The short term effects of a Wilbarger Deep Tactile and Proprioceptive Technique (DTPT) on behavioural modulation and sympathetic arousal in children aged 4-8 years with sensory processing difficulties."

The Wilbarger deep pressure and joint compression regime, otherwise referred to as brushing, is primarily for treating sensory overresponsiveness. This passive intervention is recommended to treat modulation of the tactile system in a child with tactile defensiveness, although also influencing other systems since sensory overresponsiveness is characterised by vulnerability to touch, taste, vision, sound, and vestibular sensation.

I would like to invite you and your child to participate in this study and assist me in my investigation.

I am requesting that you complete a brief questionnaire to obtain demographical information and provide details related to the Wilbarger DTPT, regarding previous or current use with your child as part of their occupational therapy intervention approach. Additionally, a Short Sensory Profile will need to be completed by you in order to determine your child's reactivity to sensory stimulation as he/she is presently functioning, all of which should take approximately 20 minutes of your time. I am also requesting your permission to obtain your child's most recently completed Sensory Profile from his/her treating occupational therapist. The information from this questionnaire and their sensory profiling will be used to establish if your child still meets the inclusion criteria for the study. According to this, your child may or may not be recruited for this research. The inclusion/exclusion of your child will be confirmed once you return these forms to the researcher.

During the process of data collection, the Wilbarger DTPT (i.e., brushing) will be administered to your child by an experienced occupational therapist. This involves deep pressure input applied using a specific, non-scratching therapressure brush

followed by systematic joint compressions to all major joints in the body (please see pictures attached). Please be aware that the brush is applied directly to the surface of the skin using a specific, consistent technique. A separate brush will be used for each child. Your child will need to wear shorts and a T-shirt and be barefoot during the brushing session to make it easier for the therapist to brush their back and upper and lower limbs, as other areas of the body are avoided when using this technique.

The study aims to measure changes in behaviour before and after administering the Wilbarger DTPT. Your child will be involved in an Activity protocol engaging in different table-top tasks (puzzles, blocks, colouring) at different stations, and will rotate as a group between these activities. During this time the behaviour of each participant will be video recorded. The 15-minute Activity protocol will be conducted twice - before and after exposure to the intervention - and both sessions will be recorded.

The study will further investigate if there are short-term physiological changes following a single application of the Wilbarger DTPT by measuring the change in salivary cortisol levels. Your child will be asked to spit into a plastic tube before and after they have received the intervention (DTPT).

The data will be collected on one school day, immediately after school has ended, during a 45-minute group session commencing from 14h00 after the children have had lunch. I am requesting that you arrange for your child to be collected by 15h00. The research procedure will incur no cost to you as a parent.

Please note that stringent steps will be taken to ensure ethically correct procedures in video recording and obtaining saliva samples, which will be stored together at the University of the Witwatersrand for 6 years or for 2 years after publication.

Please be advised that you and your child's participation is voluntary and your child will also be asked to give assent to take part. You and your child may withdraw at any point in the research without consequence. There is no direct benefit for your child in receiving the intervention once in this study.

Efforts will be made to ensure confidentiality throughout the study as no names will be used in the data collection process. Instead, participant codes will be assigned as a subject number to each child, which will refer to that child in the entire research

process. Only the researcher will keep the identifying information for these codes. Video tapes necessary to capture behavioural data, will be seen for analysis by qualified occupational therapists who understand the importance of professional confidentiality. Your child will be asked to wear a sticker with his or her participant code showing on his or her front for the purpose of analysing his or her behaviour in the video recordings taken. Feedback from the study will be available on request.

If you have any further queries please do not hesitate to contact me on 082 452 7212, I would be happy to answer any of your questions.

If you have any concerns about the ethics of the study you may contact Prof P Cleaton-Jones, the chairman of the Human Research Ethics Committee at 011 717 1234 or anisa.keshav@wits.ac.za,

If you agree to your child's participation in the study please complete the attached consent forms, parent questionnaire and the Short Sensory Profile providing as much detail as possible.

I appreciate your time.

_____

G. Irving

B.Sc (OT) UCT

Informed Consent

I _____ agree to take part in the study and to allow my child, _____, to participate in the study investigating "The short-term effects of a Wilbarger Deep Tactile and Proprioceptive Technique on behavioural modulation and sympathetic arousal in children aged 4-8 years with sensory processing difficulties," for which I have read all the information concerning this research in the information document.

Parent/Guardian: _____

Signature: _____

Date: _____

APPENDIX E

Consent to allow the collection of saliva samples.

I, _____ the parent/ guardian of _____ hereby grant permission for my child to give two saliva samples for the purposes of this research as explained in the information document. I understand that these samples will be stored at the University of the Witwatersrand for the duration of the study and analysed by the primary researcher and an assistant from the Physiology department, and will be destroyed following completion of the research.

Signature: _____

Date: _____

APPENDIX F

Consent to be videotaped.

I, _____ the parent/ guardian of _____ hereby grant permission for my child's behaviour to be videotaped during a supervised group session while engaging in an Activity protocol. I understand that two separate recordings will be taken of my child prior to and following administration of the Wilbarger DTPT. I am aware that the videotapes will be stored at the University of the Witwatersrand for the duration of the study. I understand confidentiality cannot be ensured but that only the primary researcher and one other occupational therapist will view the tapes.

Signature: _____

Date: _____

Consent to be videotaped.

(Pilot study)

I, _____ the parent/ guardian of _____ hereby grant permission for my child's behaviour to be videotaped during a supervised group session while engaging in an Activity protocol. I understand that this video recording may be used for the main study as well as the pilot study to this research. If the videotape of my child is selected for the purposes of the pilot study, the two sessions (both pre- and post-test) of 15 minutes each will be watched by a panel of four occupational therapists who are qualified in sensory integration. I realise that this is a necessary step in the research procedure in order to adapt the behavioural scale, for more appropriateness, to be used in the study. I am aware that the videotapes will be stored at the University of the Witwatersrand for the duration of the study and will be destroyed following completion of the research. I understand that confidentiality cannot be ensured but give permission for four other occupational therapists to view the tapes (for use in the pilot study), as well as the primary researcher and a different occupational therapist (for data collection for the main study).

Signature: _____

Date: _____

APPENDIX G

Verbal assent from each child

Hello (name of child)

My name is Genna and I will be coming to visit your therapy room on one afternoon to spend some time with you and two other occupational therapists will come with me. We want to do some activities with you and some of the other children that are from your school will also be a part of our group. If you do not want to be a part of this group then you can tell me that now or even later if you change your mind, but you will not get into any trouble if you don't want to come.

When you come to the group we will play games that you have in your classroom and one of us will use a special brush to brush your arms, legs, hands and feet like a massage. Once we have used our special brush we will "pump your muscles" (demonstrate joint compressions) to see how strong you are and all of us will have a turn. Once our bodies have been brushed we want to also see how well we can all brush our teeth. After we pretend to give our teeth a good brush, and show one another how we do it, we can all spit out to clean our mouths. Do you want to come join us, and some of your friends, to do all of this?

While we will be doing this I want to put us on video so that we can remember what happened in our group. I will use cameras to film us like the movies you watch on TV.

Remember, you don't have to come if you don't want to - you can tell me any time, okay? Do you understand?

Child's name/ signature _____

_____

Researcher_____

Date_____

Witness_____

Date_____

APPENDIX H

PARENT QUESTIONNAIRE

Identifying Information

To be kept separate

Questionnaire Code: _____

Personal Details:

Child's name & surname: _____

Questionnaire Number: _____

PLEASE COMPLETE THIS FORM BY PROVIDING AS MUCH DETAIL AS POSSIBLE. THE INFORMATION OBTAINED FROM YOUR RESPONSES WILL ASSIST THE RESEARCHER IN MAKING ASSOCIATIONS BETWEEN THE RESULTS FOUND IN THE STUDY AND THIS PARTICULAR INFORMATION ABOUT YOUR CHILD. FURTHERMORE, THE EXTRANEOUS VARIABLES THAT MAY CONFOUND RESULTS WILL BE TAKEN INTO ACCOUNT BY CONSIDERING YOUR RESPONSES TO THESE QUESTIONS. PLEASE BE AWARE THAT YOUR IDENTIFYING INFORMATION AND RESPONSES IN THIS FORM WILL REMAIN CONFIDENTIAL THROUGHOUT THE RESEARCH.

Personal Details:

1. Age: _____
1. Gender: _____
2. Grade: _____

Medical History:

3. Has your child ever received a medical diagnosis made by a psychiatrist or suffered from a general medical condition in the past or at present? If yes, please specify.

   Yes ☐ No ☐

   _____

4. Is your child currently on any medication? Yes ☐ No ☐

   If yes, please give the name, exact schedule and dosage of the medication(s) currently being taken?

   _____

5. When did your child first start receiving occupational therapy? _____

   Please provide specific details concerning the main problems for which your child was referred to occupational therapy and how long they have been receiving OT?

   _____

   _____

   _____

   _____

6. Has your child received a diagnosis of sensory modulation dysfunction? If yes, what specific sensory processing difficulties did he or she present with to indicate this diagnosis (vulnerability/reactivity to touch, taste, vision, sound and vestibular sensation)?

_____

_____

_____

THE WILBARGER DEEP TACTILE AND PROPRIOCEPTIVE TECHNIQUE:

7. When did your child receive the Wilbarger Deep Tactile and Proprioceptive Technique, either in therapy or at home (please provide dates)?

   Therapy ☐ Home programme ☐ Both ☐

   Dates: _____/_____/_____ to _____/_____/_____ or still currently receiving ☐

8. Who was involved in administering the Wilbarger Deep Tactile and Proprioceptive Technique to your child (therapist, caregiver, teacher)?

   _____

9. If you were asked to use the Wilbarger Deep Tactile and Proprioceptive Technique as a home programme, did you receive any training in how to administer it correctly from the child's occupational therapist? (Please specify if given once-off or continually supervised/discussed with you by the therapist).

   _____

   _____

   _____

10. What was your general perception of the Wilbarger Deep Tactile and Proprioceptive Technique; did you find it helped your child in any way? If so, please indicate how?

    _____

    _____

    _____

    _____

11. If used as a home programme, how many times during the day did you administer the Deep Tactile and Proprioceptive Technique to your child? Please state if this changed from the amount of applications given initially when starting the regime with your child?

    _____

    _____

    _____

12. What were the positive and negative aspects regarding use of this Deep Tactile and Proprioceptive Technique in your home environment as a home programme (time taken to administer, fitting it into daily routines, child's willingness to be "*brushed*")?

_____

_____

_____

13. What feedback, if any, did your child's teacher give regarding the effect on your child if used during class?

_____

_____

_____

14. How did your child respond to this Deep Tactile and Proprioceptive Technique, in therapy and when used at home? (If given as a home programme).

_____

_____

_____

School History:

15. Does your child have any reported or observed anxieties related to his or her school performance?

_____

_____

_____

16. How would you describe your child in terms of his or her temperament in relating to peers/siblings (quiet, withdrawn, outspoken, dominating)?

_____

_____

_____

17. Has your child's activity levels (hyperactive or underresponsive) ever been discussed with you as being a problem in the class or negatively impacting his or her work performance? Please elaborate if yes.

_____

_____

_____

Social History:

18. Have there been any significant stressors experienced by your child or in your home recently that may have influenced your child in any way? If so, how long ago was this and what was involved? (If you are able to share the details).

_____

_____

_____

General:

19. Please describe your child's organisation within the home and in his or her approach to tasks:

_____

_____

20. How would you describe your child's routines in the following activities of daily living:

Eating

_____

Sleeping

_____

Bathing

_____

Dressing

_____

21. Does your child present with performance or generalised anxiety? Please specify.

_____

_____

Thank you for giving up your time to complete this questionnaire.

APPENDIX IA

SHORT SENSORY PROFILE (SSP)

Identifying Information

To be kept separate

Participant Code: _____

Personal Details:

Child's name & surname: _____

Short Sensory Profile

SENSORY PROFILE

Winnie Dunn,
Ph.D., OTR, FAOTA

Participant code_____

INSTRUCTIONS

Please check the box that best describes the frequency with which your child does the following behaviors. Please answer all of the statements. If you are unable to comment because you have not observed the behavior or believe that it does not apply to your child, please draw an X through the number for that item. Please do not write in the Section Raw Score Total row.

Use the following key to mark your responses:

- **ALWAYS** — When presented with the opportunity, your child always responds in this manner, 100% of the time.
- **FREQUENTLY** — When presented with the opportunity, your child frequently responds in this manner, about 75% of the time.
- **OCCASIONALLY** — When presented with the opportunity, your child occasionally responds in this manner, about 50% of the time.
- **SELDOM** — When presented with the opportunity, your child seldom responds in this manner, about 25% of the time.
- **NEVER** — When presented with the opportunity, your child never responds in this manner, 0% of the time.

Item	Tactile Sensitivity	ALWAYS	FREQUENTLY	OCCASIONALLY	SELDOM	NEVER
1	Expresses distress during grooming (for example, fights or cries during haircutting, face washing, fingernail cutting)					
2	Prefers long-sleeved clothing when it is warm or short sleeves when it is cold					
3	Avoids going barefoot, especially in sand or grass					
4	Reacts emotionally or aggressively to touch					
5	Withdraws from splashing water					
6	Has difficulty standing in line or close to other people					
7	Rubs or scratches out a spot that has been touched					
	Section Raw Score Total					

Item	Taste/Smell Sensitivity	ALWAYS	FREQUENTLY	OCCASIONALLY	SELDOM	NEVER
8	Avoids certain tastes or food smells that are typically part of children's diets					
9	Will only eat certain tastes (list: _____)					
10	Limits self to particular food textures/temperatures (list: _____)					
11	Picky eater, especially regarding food textures					
	Section Raw Score Total					

Item	Movement Sensitivity	ALWAYS	FREQUENTLY	OCCASIONALLY	SELDOM	NEVER
12	Becomes anxious or distressed when feet leave the ground					
13	Fears falling or heights					
14	Dislikes activities where head is upside down (for example, somersaults, roughhousing)					
	Section Raw Score Total					

Item	Underresponsive/Seeks Sensation	ALWAYS	FREQUENTLY	OCCASIONALLY	SELDOM	NEVER
15	Enjoys strange noises/seeks to make noise for noise's sake					
16	Seeks all kinds of movement and this interferes with daily routines (for example, can't sit still, fidgets)					
17	Becomes overly excitable during movement activity					
18	Touches people and objects					
19	Doesn't seem to notice when face or hands are messy					
20	Jumps from one activity to another so that it interferes with play					
21	Leaves clothing twisted on body					
	Section Raw Score Total					

0761638199

Item	Auditory Filtering	Always	Frequently	Occasionally	Seldom	Never
22	Is distracted or has trouble functioning if there is a lot of noise around					
23	Appears to not hear what you say (for example, does not "tune-in" to what you say, appears to ignore you)					
24	Can't work with background noise (for example, fan, refrigerator)					
25	Has trouble completing tasks when the radio is on					
26	Doesn't respond when name is called but you know the child's hearing is OK					
27	Has difficulty paying attention					
	Section Raw Score Total					

Item	Low Energy/Weak					
28	Seems to have weak muscles					
29	Tires easily, especially when standing or holding particular body position					
30	Has a weak grasp					
31	Can't lift heavy objects (for example, weak in comparison to same age children)					
32	Props to support self (even during activity)					
33	Poor endurance/tires easily					
	Section Raw Score Total					

Item	Visual/Auditory Sensitivity					
34	Responds negatively to unexpected or loud noises (for example, cries or hides at noise from vacuum cleaner, dog barking, hair dryer)					
35	Holds hands over ears to protect ears from sound					
36	Is bothered by bright lights after others have adapted to the light					
37	Watches everyone when they move around the room					
38	Covers eyes or squints to protect eyes from light					
	Section Raw Score Total					

FOR OFFICE USE ONLY

Summary

Instructions: Transfer the score for each section to the Section Raw Score Total column. Plot these totals by marking an X in the appropriate classification column (Typical Performance, Probable Difference, Definite Difference).*

SCORE KEY

1 = Always	4 = Seldom
2 = Frequently	5 = Never
3 = Occasionally	

Section	Section Raw Score Total	Typical Performance	Probable Difference	Definite Difference
Tactile Sensitivity	/35	35 — 30	29 — 27	26 — 7
Taste/Smell Sensitivity	/20	20 — 15	14 — 12	11 — 4
Movement Sensitivity	/15	15 — 13	12 — 11	10 — 3
Underresponsive/Seeks Sensation	/35	35 — 27	26 — 24	23 — 7
Auditory Filtering	/30	30 — 23	22 — 20	19 — 6
Low Energy/Weak	/30	30 — 25	24 — 24	23 — 6
Visual/Auditory Sensitivity	/25	25 — 19	18 — 16	15 — 5
Total	/190	190 — 155	154 — 142	141 — 39

*Classifications are based on the performance of children without disabilities ($n = 1,037$).

281070-1 321 22 23 24 25 26 27 28 29 30 31 32 A B C D E

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APPENDIX IB

SENSORY PROFILE (SP)

Identifying Information

To be kept separate

Participant Code: _____

Personal Details:

Child's name & surname: _____

SENSORY PROFILE

Winnie Dunn, PhD. OTR, FAOTA

CAREGIVER QUESTIONNAIRE

Child's Name: _____

Birth Date: _____

Date: _____

Completed by: _____

Relationship to Child: _____

Service Provider's Name: _____

Discipline: _____

INSTRUCTIONS

Please check the box that **best** describes the frequency with which your child does the following behaviours. Please answer all of the statements. If you are unable to comment because you have not observed the behaviour or believe that it does not apply to your child, please draw an X through the number for that item. Write any comments at the end of each section. Please do not write in the Section Raw Score Total row.

Use the following key to mark your responses:

Always	When presented with the opportunity, your child always responds in this manner, 100% of the time.
Frequently	When presented with the opportunity, your child frequently responds in this manner, about 75% of the time.
Occasionally	When presented with the opportunity, your child occasionally responds in this manner, about 50% of the time.
Seldom	When presented with the opportunity, your child seldom responds in this manner, about 25% of the time.
Never	When presented with the opportunity, your child never responds in this manner, 0% of the time.

APPENDIX J

Adapted Daily Behaviour Assessment Scale

Identifying Information

To be kept separate

Participant Code: _____

Personal Details:

Child's name & surname: _____

DAILY BEHAVIOUR ASSESSMENT SCALE

Participant Code: _____

Please tick each time a behavioural item is observed and total the score in the final column.

	Item	1	2	3	4	5	6	7	8	9	10	**Total Score**
Concentration, Attention, and Readiness for task												
1	Easily distracted by own thoughts, daydreams											
2	Looks away from task to notice all actions in the environment (things s/he hears or sees). Distracted easily by external stimuli.											
3	Appears to be bored, lacks motivation.											
4	Needs instructions repeated.											
5	Has difficulty paying attention (internal distraction).											
6	Low arousal/ hypo-responsiveness/ decreased postural adjustments to task (unaware of body's position in space/relation to task).											
7	Poor maintenance of seated posture (exaggerated movements used, fixating or slouching in seat).											
8	Fails to notice opportunities for engagement.											
Behaviour in Group												
9	Restless, overactive											
10	Gets out of seat, needs to move around, wanders/explores.											
11	Disrupts group, disturbs others.											
12	Demands to be in the spotlight, seeks attention.											
Perseverance and Task Completion												
13	Easily frustrated when attempting tasks.											
14	Gives up easily and fails to complete the task.											
15	Showing avoidance of tasks presented.											
16	Transitioning between tasks without completing given task.											
Organisational Ability												
17	Disorganised on self, and in his/her work, work lacks planning.											
18	Can't get down to his/her work.											
19	Slow to complete a task.											
20	Requires step-by-step instructions.											
21	Impulsive, works too fast.											
22	Requires mediation.											
Ability to Cope with New Situation												
23	Refuses to attempt new tasks, persists only with easy tasks.											
24	Becomes overexcited, lacks self-control.											
25	Appears anxious, lacks confidence and withdraws.											
26	Takes control of the situation and those around him/her.											
27	Can't cope with a number of different stimuli at the same time.											

Social Interaction												
28	Isolates him/herself from others.											
29	Is aggressive or rough with others (lashing out or antagonising others).											
Responsibility, Initiative												
30	Unable to initiate activities.											
31	Unable to carry task out independently.											
32	Seeks reassurance & affirmation during tasks.											
Self-regulation												
33	Uses movement (fidgets, rocking on chair, shifting body, swaying)											
34	Uses proprioceptive/tactile/oral input (stamping feet, sucking on objects/fingers, pulling, touching or rubbing self/objects).											
35	Uses auditory input (whistling, making noises, singing)											

APPENDIX K

The Wilbarger Deep Tactile and Proprioceptive Technique (DPPT).

The deep pressure and proprioceptive-based technique, referred to as brushing, is an intensive approach to treat children who present with sensory overresponsiveness. This intervention is essentially a combined approach involving the therapist and parent, but relies heavily on the caregiver's involvement to implement and use the Deep Tactile and Proprioceptive Technique within daily routines.

The approach, applying very deep pressure input to the skin and proprioception through systematic joint compressions, is considered to have a desensitising effect on the nervous system of a child who is generally overresponsive to sensation. Specifically, this intervention was developed to treat children with atypical reactivity, generally in the tactile system and referred to as tactile defensiveness, although not limited to the tactile system. By providing the child with this "calming and organising" sensory input, it is thought to positively influence anxiety (commonly associated with defensiveness), improve disorganisation, and decrease distractibility.

The first step in the Deep Tactile and Proprioceptive Technique involves application of very deep pressure using a specific, manufactured, non-scratching therapressure brush. This is applied first to the skin on one arm and hand, then to the back, and again to the skin on the other arm and hand, ending with application to both legs and feet. Importantly, an appropriate amount of pressure should be exerted against the skin, to the point that the bristles of the brush are completely bent or are flat against the skin while moving the brush. The brush should not be lifted off the skin during the entire process when applying the deep pressure input to the surface area of each body part. The therapressure brush should be held in a horizontal direction throughout application with movement of the brush being consistent, uninterrupted, and methodical using long sweeping strokes as far as possible. The tactile input is never applied to the stomach, groin, buttocks, head, or face. The therapressure brush should not cross over from skin onto clothing. Therefore, the child should be asked to pull up sleeves or remove necessary clothing (i.e., a jacket) prior to commencing the technique. In order to avoid fleeting light touch on the child, this should not be done by the therapist

Immediately following this step in the intervention, gentle compressions to all the major joints in the body are systematically applied; this includes the fingers, wrist, elbows and then shoulders, followed by compressions to the hips, ankles and knees. The therapist applies up to ten consecutive compressions to each joint. Lastly, the therapist should end with three quick, succinct compressions to the chest, placing one hand on the front and back of the child. The compressions explained provide the proprioceptive input of the deep tactile and proprioceptive technique.

To complete this entire routine would take approximately three minutes for an experienced clinician or caregiver. Incorporating this technique into a sensory diet schedule carried out as part of daily routines, enhances the effect of the intervention. Initially, when the regime is initiated with a child it should be applied frequently for the first two weeks, usually every 1 ½ to 2 hours (approximately six times per day) as recommended by the Wilbargers. After this time a change can be expected, although the programme may be continued for up to a month, after which it is usually modified by the treating occupational therapist. The frequency may then be reduced and used as and when needed by the child, depending on the situation-specific demands. However, the whole Wilbarger protocol is structured to be used in this way in order to change and shift the child's nervous system responses(Wilbarger and Wilbarger, 2012b). If used intensively, the effect of the Deep Tactile and Proprioceptive Technique should be maintained but may continue to be used as a calming or preparatory intervention within daily activities.

Children who take longer than usual to respond positively or who resist initially may need to be distracted through use of a fidget or mouth toy to play with, and may even require auditory integration therapy prior to commencing this treatment technique. This response can be expected in some children; seldom children react negatively and resist it, while others seek out the input applied through the Deep Tactile and Proprioceptive Technique. However, because this is a therapist-guided intervention, the use of it with children who continue to resist or who show negative changes should be reconsidered. This would be especially essential in the case of a caregiver administering the technique. Changes noted should constantly be discussed with the supervising occupational therapist recommending the treatment schedule. Continuous supervision and training from the occupational therapist for the necessary caregivers

involved in the Wilbarger protocol are essential elements that often determine the success of this intervention when used in practice.

The specific steps followed by the occupational therapist who administered the Deep Tactile and Proprioceptive Technique in this research study are represented below:

APPENDIX L

Procedure Followed for Collection and Storage of Saliva Samples, Outlined by Salimetrics, LLC.

<table>
<tr><th colspan="2">Prior to collection</th></tr>
<tr><td rowspan="3">Each child was required to rinse his/her mouth out thoroughly with water before the group commenced (approx. 10 minutes before collection of saliva). Each child was given a “chew” to chew on to generate saliva while being brushed.</td><td>All samples were taken 60 minutes after ingestion of a major meal.</td></tr>
<tr><td>Dairy products were avoided on the day of sample collection to prevent bovine hormones cross-reacting with anti-cortisol antibodies in the saliva samples, which may have caused false results.</td></tr>
<tr><td>High acidic or sugar foods were restricted and were not ingested 60 minutes before collecting samples, as these lower saliva pH levels influencing bacterial growth.</td></tr>
<tr><th colspan="2">Specimen collection</th></tr>
<tr><td colspan="2">Children were moved to the bathroom area within the therapy centres and asked to pretend they were brushing their teeth (with a dry toothbrush, no toothpaste or water), as part of the steps related to their immediate occupational experience. After this, each child was asked to spit into plastic specimen bottles. This procedure was carried out in the same manner for collection of both the pre-and post-test measures. The post-test measure was taken approximately 15-20 minutes following the intervention, as changes in cortisol levels register 5 minutes after stimulation and peak in saliva 15-20 minutes after this.</td></tr>
<tr><th colspan="2">Sample Handling</th></tr>
<tr><td colspan="2">After saliva collection, salivary swabs were dated and coded, with the time of specimen collection recorded.</td></tr>
<tr><td colspan="2">Samples were kept cold by refrigerating them in the therapy centres in order to avoid bacterial growth in the specimen; this step was necessary 30 minutes after collection. Following this, samples were frozen at or below -20° within 4 hours after collection in the physiology department at the university. Samples can be stored at this temperature for long-term storage.</td></tr>
</table>

Analysis using ELISA: High sensitivity enzyme-linked immunosorbent assay kit
Optical density values based on the amount of cortisol in the sample was determined for the baseline and post-test measures (not in duplicate). The primary researcher and assistant physiologist followed the steps in the guidelines outlined by Salimetrics for reagent preparation from at the University of the Witwatersrand.