Exploring Sensory Processing among Hearing Impaired and Culturally Deaf Children

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"Get 'em in, get 'em in….Bring your people with you…Bring anyone who has ever loved you" (Angelou, 1992)

Contained within the pages of this thesis is a journey I have not walked alone. In coming to express my thanks and acknowledge the contributions of everyone who made this work possible I found myself travelling down an ever-stretching, bustling road. When I turned to look back along that road to where I had come from, not even a step from where I stood I found Keith and Amanda; supervisors who have supported and nurtured this project and me alongside it, who navigated the twists, turns, and stumbling blocks we have faced with ingenuity, warmth, pragmatism, and humour. Next to them, good-naturedly teasing each other in their usual way stood my partner, Kishan, and my mum. Because of them I have reached this point of my journey whole and balanced, powered by tea and biscuits. Turning my head just slightly I could see an open, welcoming group of parents walking hand-in-hand with their children. Weaving among them, a collection of teachers, TA's, and charity workers could be seen holding my recruitment posters high. A few steps further down the road I found Jenna, who righted me when the wheels started to fall off. Standing alongside her were Helen and Lizette; DClin's research Marshallers helping land projects safely with smiles and luminous wands. As I continued, I felt the presence of my friends from the course each walking their own paths next to me and each a warm beacon of companionship reminding me I was never really alone. On the side of my own path I saw Lisa and Mark, Laura A., Amy, Vanessa, Francesca, and Laura D., the whole Coulson Clan and the entire Thaker Tribe flickering and twinkling. Like images projected by an endlessly spinning lantern they flowed with me, waving banners, and singing songs, at their brightest when things were darkest. All along my road I met clients, mentors, teachers, supervisors, colleagues, and friends. People I have known recently and people I reconnected with by retracing the steps along my road. Pam, George, and Flo. Roy and Joan. Lesley. Lorena, Sandra, and Jeanette. Shirley, Joanna, and Karen. Velia, Evelyn and Máiréad. Jude. Maria, Jorge, and Saskia. Wendy. Adrian and Alex. The WWH assistants gang. Others whose names I cannot share but who I keep in memory. A humbling host, most of who have never met but upon whose generosity, patience, and faith the foundations of my research and clinical skills, and who I am as a person, rest.

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GLOSSARY OF TERMS

The terms used within this thesis are defined within the text. However, for those with limited knowledge of deafness and the Deaf some definitions are offered immediately in the hopes these provide a foundation for engagement with and enjoyment of this thesis. To that end, definitions are offered thematically rather than alphabetically.

deafness – When written with a lowercase “d” the term deafness refers to abilities related to detecting sounds in the environment that fall beneath specified thresholds. This conceptualisation is rooted in a medical view of deafness as a disability. A person medically considered to have impaired levels of hearing is referred to as being deaf. Usually deaf people subscribe to this view and consider themselves to be disabled. People who are deaf tend to become so later in life, although not exclusively, and typically use spoken or written languages to communicate. Often deaf people develop or retain an identity related to dominant (hearing) groups in their society.

Hearing impaired - a synonym for deafness or being deaf.

Deafness - When written with an uppercase “D” the term Deafness refers to a specific cultural identity. Deaf cultures include a set of social beliefs, behaviour, art, literary traditions, history, and values which can differ from other cultural groups in a society. An important aspect of Deaf culture is the use of a signed language as a primary means of communication. As such Deaf people are considered a linguistic and cultural minority group. Often Deaf people are born Deaf or deaf, or become deafened in early childhood, often prelingually. They do not tend to consider themselves disabled. For many Deaf people in the UK, English is a second language at best and not necessarily one they obtain fluency in.

d/Deaf – a term used to refer to deaf and Deaf people simultaneously.

hearing – a term used in Deaf communities to describe people who are not d/Deaf.

Hearing – akin to the capitalisation of ‘*White’* or ‘*Male’* by theoreticians exploring other areas of privilege (e.g. the ‘Hearing world’ or ‘Hearing way’)

deafblind - a person with a combination of sight and hearing loss.

Signed Languages – visual languages based on hand movements and shapes, facial expression, and body language rather than spoken words. It is estimated that there are between 138 and 300 different signed languages in the world today.

British Sign Language (BSL) - the UK's official signed language. Records of signed language in England date as far back as 1570, with scholars agreeing its use likely significantly predated this. Despite this BSL was not officially recognised by the British Government as a minority language until 2003. From 1880 until the 1940s sign language was effectively banned in the western world and primarily survived by being covertly passed on by Deaf people living in residential institutions. There are regional dialects of BSL, similar to accents in spoken English, with some signs occurring only in certain regions, towns, or cities. Like words in spoken English, signs come and go, evolving over time (e.g. “toast” which has changed from hand shapes demonstrating bread sliding under a grill to bread popping up from a toaster), with new signs created as needed (e.g. “Internet” or “social media”). Family units also tend to create signs which are unique to them. These are known as “home signs” and are often developed and used by families to compensate for a lack of fluency in a signed language.

Sign Supported English (SSE) - a form of communication “borrowing” signs from BSL but fitting them to the grammar and structure of spoken English. SSE is not a form of BSL and can best be thought of as a language system which uses a form of manually coded English.

Makaton – a language system using symbols, single signs, and speech to enable communication.

Total Communication - an approach to educating d/Deaf children which makes use of different modes of communication including signing, speaking, lip-reading, written languages, and visual aids tailored to the needs and abilities of a child.

Cochlear Implants - an implanted medical device designed to produce useful hearing sensations for a person with severe-to-profound nerve deafness by electrically stimulating nerves inside the inner ear.

Audism - a term used to describe negative attitudes and prejudice toward d/Deaf people that can lead to discrimination, marginalisation, disempowerment, and exclusion.

ABSTRACT

It is estimated that 5-10% of the non-clinical paediatric population experience difficulties with sensory processing (SP). In some clinical groups 90-95% of children are estimated to experience difficulties in this area. SP needs correlate with higher rates of mental health difficulties. Deaf and hearing-impaired children experience at least one sensory input differently than the general population. They are also more vulnerable to mental health difficulties than their hearing peers. SP needs among Deaf and hearing-impaired children have never been explored.

Aim: This study explored SP and mental wellbeing among 5 to 10-year-old Deaf and hearing-impaired children.

Method: A quantitative, within group design (N = 21) was used. Scores from two parent-rated measures routinely used in clinical and research settings were analysed using descriptive and inferential statistics. These measures were the Sensory Profile Caregiver Questionnaire and the Strengths and Difficulties Questionnaire.

Results: In each area of SP 19 - 76% of the Deaf and hearing-impaired sample demonstrated ‘atypical’ responses. Mean SP scores for the Deaf and hearing-impaired children differed significantly from norms for typically developing children and those with a diagnosis of ASD and a diagnosis of ADHD. Children using hearing aids showed greater difficulties in two SP areas compared to those using cochlear implants. Degree of hearing loss and sign language use were not found to impact SP. SP scores explained a significant proportion of variance in scores related to mental wellbeing.

Conclusion: Cautiously it is suggested that Deaf and hearing-impaired children may have a unique SP profile, SP may be influenced by the use of hearing equipment, and there is a link between SP needs and mental wellbeing among these children. More research across the lifespan including research into assessment and interventions is needed.

TABLE OF CONTEXT

THANKS AND ACKNOWLEDGEMENTS **1**

GLOSSARY OF TERMS **2**

ABSTRACT **4**

TABLE OF CONTEXT **5**

INDEX OF TABLE **9**

TABLE OF FIGURES **11**

CHAPTER 1 - INTRODUCTION **12**

Foreword **12**

Ontology, Epistemology, and Me **12**

A Critical Realist Approach. ***12***

Me, Myself & My Research. ***13***

Sensory Processing **14**

Introduction to Sensory Processing. ***14***

Sensory Processing Disorder: A Critical Realist Perspective. ***16***

Sensory Processing in Specific Paediatric Populations. ***17***

Children with a diagnosis of ASD. *18*

Children with a diagnosis of ADHD. *18*

Other Groups of Children. *19*

Intervention for Sensory Processing Needs. ***20***

Introduction to d/Deafness **21**

Measuring deafness ***21***

deaf or Deaf? ***23***

The Deaf Community in the UK: Historical and Modern Contexts. ***23***

Mental Health. ***24***

d/Deafness and Sensory Processing **27**

The Dangers of Paving with Good Intentions **29**

Chapter Summary **31**

CHAPTER 2 - LITERATURE REVIEWS **32**

The Systematic Review: Sensory Processing Among d/Deaf People **32**

Search Strategy. ***32***

Findings. ***35***

Visual Processing *35*

Balance and Motor Skills. *36*

Foreword: vestibular disorders. 36

Balance. 36

Motor. 38

Tactile Processing. *38*

Olfactory Processing. *40*

Oral Sensitivity, Auditory Processing, and Mental Health. *41*

Sensory Processing and d/Deaf Children. *41*

Summary ***42***

The Scoping Review: Sensory Processing and Mental Wellbeing **43**

Search Strategy. ***43***

Findings. ***48***

Overall Summary **49**

Rationale and Research Aims **50**

CHAPTER 3 - METHOD **51**

The Original Plan **51**

The Current Study **52**

Research Questions ***52***

Research Design ***52***

Ethics ***53***

Recruitment ***53***

…and then Covid-19 .... ***53***

Participants ***54***

Inclusion/Exclusion Criteria ***54***

Instruments ***54***

Strengths and Difficulties Questionnaire. *55*

The Sensory Profile Caregiver Questionnaire. *55*

Procedure ***56***

Analytical Strategy ***58***

CHAPTER 4 - RESULTS **59**

Demographic Information **59**

Comparing the Sensory Processing Profiles of d/Deaf Children **61**

Categorisations of Sensory Profiles. ***61***

Item Scores. *61*

Factor Scores. *61*
Quadrant Scores. *61*
Statistical Comparisons with Typically Developing and Atypical Populations. ***63***
Item Scores. *63*
Typically Developing Children........ 63
Children with a Diagnosis of ASD. 63
Children with a Diagnosis of ADHD. 64
Factor Scores. *66*
Typically Developing Children........ 66
Children with a Diagnosis of ASD. 66
Children with a Diagnosis of ADHD. 66
Summary of Comparisons. ***67***
The Impact of Degree of Hearing Loss, Equipment Use, and BSL Use **69**
The Impact of Sensory Processing on Psychological Distress **70**
Mental Wellbeing: SDQ Scores ***70***
Sensory Processing and Mental Wellbeing: Three Regression Analyses ***70***
Items Regression. *70*
Descriptive Statistics........ 71
Regression Statistics. 75
Summary 78
Factor Regression. *79*
Descriptive Statistics........ 79
Regression Statistics. 81
Quadrant Regression. *83*
Descriptive Statistics........ 83
Regression Statistics 85
Summary of Regression Analyses. *87*
Overall Summary of Results ***89***
Comparison of Sensory Profiles. *89*
Degree of Hearing Loss, Equipment, and BSL Use. *89*
Sensory Processing and Mental Health. *89*
CHAPTER 5 - DISCUSSION **90**
Discussion and Interpretation of Results **90**
Sensory Processing Profiles: Response to Sensory Stimuli among d/Deaf Children. ***90***
Auditory Processing. *91*

Visual Processing......91
Vestibular Processing.......92
Tactile Processing......92
Oral Processing.......93
Overview of Processing.......93
Modulation, and Behavioural and Emotional Responses......93
Factors and Quadrant Responses.......95
Sensory Processing Profiles: Comparison with Other Groups.......97
Degree of Hearing Loss, Equipment, and BSL Use.......97
Sensory Processing and Mental Health.......98
Level if Difficulty......98
Emotional Difficulties.......98
Hyperactivity.......99
Prosocial Behaviour.......99
Conduct and Peer Relationships.......100
Coulda, Woulda, Shoulda: Beneficial Changes and Future Commitments.......100
Clinical Implications......102
Conclusion......103
Overall Summary and Recommendations......104
REFERENCES......106
TABLE OF APPENDICIES......117

INDEX OF TABLE

Table 1. Dunn's Sensory Processing Model	Page 15
Table 2. Degrees of Hearing Loss (Based on Clark, 1981)	Page 21
Table 3. Search Terms used for Systematic Review	Page 33
Table 4. Systematic Review Inclusion and Exclusion Criteria	Page 33
Table 5. Search Terms used for Scoping Review	Page 44
Table 6. Scoping Review Inclusion and Exclusion Criteria	Page 44
Table 7. Summary of Research Articles from Scoping Review	Page 46
Table 8. SPCQ Items Descriptions	Page 57
Table 9. SPCQ Factor Descriptions	Page 57
Table 10 SPCQ Quadrants Descriptions	Page 57
Table 11. Age and Sex Related Demographic Information	Page 60
Table 12. Hearing Loss Related Demographic Information	Page 60
Table 13. Use and Proficiency of Signed Languages in the Home	Page 60
Table 14. Percentage of d/Deaf Children with 'Typical' and 'Atypical' Responses for each Item, Factor, and Quadrant	Page 62
Table 15. Percentage of d/Deaf Children outside of Typical Range in each area (descending on typically developing norms)	Page 62
Table 16. Mean Scores from Different Comparison Groups (Items)	Page 65
Table17. Mean Scores from Different Comparison Groups (Factor)	Page 65
Table 18. SPCQ Items and Factors with Significant Mean Differences Between d/Deaf Sample and Norms by Comparison Group	Page 68
Table 19. Effect of equipment on Endurance/Tone (Item Analysis)	Page 69
Table 20. Effect of equipment use on Low Registration (Quadrant Analysis)	Page 69
Table 21. SDQ Scores for d/Deaf children	Page 70
Table 22. Kolmogorov-Smirnov Test (*N* = 21) for SPCQ Items	Page 72
Table 23. Kolmogorov-Smirnov Test (*N* = 21) SDQ Items	Page 73
Table 24. Descriptive Statistics for SPCQ Items	Page 73
Table 25. Descriptive Statistics for SDQ Items	Page 73
Table 26. SDQ Total Score - Item Regression Model Summary	Page 76
Table 27. SDQ Total Score - Item ANOVA	Page 76

Table 28. SDQ Total Score - Item Coefficients	Page 76
Table 29. Kolmogorov-Smirnov Test (*N* = 21) for Factor Analysis	Page 79
Table 30. Descriptive Statistics for Factor Analysis of the SPCQ	Page 80
Table 31. SDQ Total Score -Factor Regression Model Summary	Page 82
Table 32. SDQ Total Score -Factor ANOVA	Page 82
Table 33. SDQ Total Score -Factor Coefficients	Page 82
Table 34. Kolmogorov-Smirnov Test (*N* = 21) for SPCQ Quadrant Analysis	Page 83
Table 35. Descriptive Statistics for SPCQ Quadrant Analysis	Page 83
Table 36. SDQ Total Score -Quadrant Regression Model Summary	Page 86
Table 37. SDQ Total Score -Quadrant ANOVA	Page 86
Table 38. SDQ Total Score - Quadrant Coefficients	Page 86
Table 39. Proportion of Variance Explained by Individual SPCQ Variables for Each Significant Regression Equation	Page 88
Table 40. Categories of Response: Sensory Processing Domains	Page 91
Table 41. Comparison of Percentage of d/Deaf Children falling in the 'Atypical' Response Range for Bharadwaj et al. (2009) and the current study (*N* = 30 and 21 respectively)	Page 93
Table 42. Categories of Response: Modulation, and Behavioural and Emotional Responses	Page 94
Table 43. Categories of Response: Factor and Quadrant	Page 94
Table 44. Impact of Sensory Processing on Hyperactivity	Page 99
Table 45. Impact of Sensory Processing on Pro-social Behaviour	Page 99

TABLE OF FIGURES

Figure 1. Examples of audiogram charts with speech banana Page 22
Figure 2. Flow of Sensory Processing Review Page 34
Figure 3. Flow of Scoping Review Page 45
Figure 4. Histogram of Auditory Processing Page 73
Figure 5. Boxplot of Visual Processing Page 73
Figure 6. Boxplot of Oral Processing Page 73
Figure 7. Boxplot of Sensory Processing Related to Endurance/Tone Page 73
Figure 8. Auditory Processing Residual Plot Page 74
Figure 9. Total SDQ Score Residual Plot Page 74
Figure 10. Factor 3: Low Endurance/Tone Boxplot Page 80
Figure 11. Factor 1: Sensory Seeking Residual Plot Page 80
Figure 12. Quadrant 1 Histogram Page 83
Figure 13. Quadrant Boxplot Page 84
Figure 14. Quadrant 1 Residual Plot Page 84

CHAPTER 1 - INTRODUCTION

"We live on the leash of our senses" (Ackerman, 1991)

Foreword

This thesis has been completed as part of a doctoral programme in Clinical Psychology at the University of Hertfordshire. It explores sensory processing needs and the impact these have on psychological distress in a sample of d/Deaf[1] children aged between five and 10. This work contains five chapters. In the first chapter the epistemological position of the study and the context in which the lead author came to the work are outlined. An introduction to the medical and cultural understandings of deafness and an overview of sensory processing are also offered. The second chapter presents systematic and scoping reviews summarising literature on the links between sensory processing and mental wellbeing among people who are d/Deaf. Chapters three and four outline the method and results of the current study. Chapter five contextualises these results and suggests ideas for future research.

Ontology, Epistemology, and Me

A Critical Realist Approach.

This work follows a critical realist philosophy. Realism research philosophies rely on the idea that reality is independent of the human mind and can be objectively and systematically studied. Broadly speaking, realism can be divided into two groups: direct and critical. Direct realism, also known as naive realism, can be summarised as "*what you see is what you get*" and postulates that "*what is*" is that which is observed. In contrast critical realism argues that, while humans do experience the sensations and images of the 'real' world, these can be deceptive and are not usually all that accurate. Defining critical realism is not an easy task as there is no unifying framework, set of beliefs, methodology, or dogma which can be directly pointed to as critical realism (Archer et al., 2016). However, one key tenant of this philosophy is the idea that ontology (the study of the nature of being) must be understood as relatively autonomous from both epistemology (what can be known) and interpretation. Joseph (2001) argues that critical realism in contrast to many philosophies of science is actually an ontological rather than epistemological approach, stating that the very practice of science indicates that the world is structured in a certain way, independent of our

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[1] d/Deaf – a term used to simultaneously refer to people who are hearing impaired and consider deafness to be a medical condition, and those with a Deaf cultural identity

knowledge of it. Critical realism contains an appreciation for the value of empirically driven positivism, the hermeneutical movement of interpretivist methodologies, and the linguistic sensitivity of postmodernism. In the social sciences hermeneutically-based methodologies are usually the starting point for critical realist research; however, engagement with these is defined in broad strokes and can be achieved through a literature review or by the use of questionnaires and interviews, and does not preclude the use of quantitative measures and statistical analysis (Price & Martin, 2018). Critical realism is defined not by particular methods but by the idea that something of the world can be known independently of interpretation provided a critical, cautious approach to causality and meaning is taken (Archer et al., 2016). I selected critical realism as the ontology for this work as it allowed for an acceptance of a real world which humans interact with via our senses as well as a contextual, experiential, culturally-bound consideration of the meaning of sensory stimuli. This approach allows for an acceptance of the idea that there are observable, measurable behavioural and neurological responses to, and in anticipation of, real sensory stimuli (Borkowska, 2017), but also that how stimuli and responses to these are experienced and interpreted may differ according to dimensions such as personal tolerance, experience, and even cultural norms.

Me, Myself & My Research.

Just as it is important for researchers to outline their epistemological, or in this case, ontological, standpoint it is also important to be transparent of the personal motivations and intent informing their work. My oldest sister was born profoundly deaf. Following her diagnosis at the age of two my mum enrolled in an evening class to learn British Sign Language (BSL) and provide my sister with an accessible language. In the 1990s there was no financial support for parents in my mum's situation and so her friends rallied to help her avoid the additional cost of a babysitter. When my twin and I were growing up there were no classes available for us, so our mum taught us BSL herself. Today parents must still muddle through learning to communicate with their d/Deaf children as best they can with little-to-no financial support. A resource my mum made use of was our local Deaf club. Deaf clubs are grassroots organisations which could, at one point, be found across the country. However, many have been forced to close due to the years of austerity and budget cuts. In the process of writing this thesis and in undertaking a specialist placement in a Deaf Child and Adolescent Mental Health service I have been reflecting on the wider social and political discourses around d/Deafness. The concept of audism "*the notion one is superior based on one's ability to hear or behave in the manner of one who hears*" (Bauman, 2004, p. 242) has been proposed as the root of the prejudice, discrimination, exclusion, and anti-Deaf rhetoric and actions within our society. There are three levels of audism: individual, institutional, and metaphysical. Individual audism refers to a hearing person without knowledge of signed languages or Deaf people's needs who maintains the status quo of a speaking society. Institutional audism relates to the structural systems which are prejudicial towards Deaf individuals such as: services refusing/limiting provision of interpreters; voice-based appointment booking systems; loudspeaker announcements; a lack of support for families with d/Deaf children; and harmful government policies. Finally, metaphysical audism refers to "*the* [philosophical] *orientation that links human identity and being with language defined as speech*" (Bauman, 2004, p. 242). This is where, in Western societies, the voice is viewed as a source of truth, being, and presence. Metaphysical audism is thought to be the root of some parents' distress that their child will never hear them say "*I love you*"; a distress suggesting that love expressed in sign is somehow love unexpressed (Bauman, 2008). Individual, institutional, and metaphysical audism all contribute to the current and historical trend of d/Deaf people being omitted from thinking around psychological distress and research. In the UK it is estimated that there are 12 million d/Deaf people (Action on Hearing Loss, n.d.). As researchers I invite you to reflect on the last time you read a paper with a d/Deaf participant. Have you ever had a d/Deaf research participant? Are your adverts accessible to Deaf people? Would you, and could you, include a d/Deaf person if they wanted to take part in your study? In the on-going struggle to ensure d/Deaf people have equal access to mental healthcare research focusing on the mental health of d/Deaf people is essential. Efforts must be made to ensure d/Deaf people do not continue to be overlooked and excluded from research because if they are then they will also continue to be excluded from the evidence base which we rely on for the development of treatments and the creation of services. In undertaking this research my motivations and intention are to highlight the experiences of culturally Deaf and hearing-impaired children in an area of research which has so far failed to include them.

Sensory Processing

Introduction to Sensory Processing.

The world is intrinsically multisensory. Our ability to interact with our world depends on the capabilities of our cognitive system to coherently identify, use, and integrate a variety of sensory inputs. Sensory processing in humans involves the reception of sensory stimuli from the environment and neurological processes that generate the conscious experience of sensation (Miller et al., 2007). It also encompasses responses to stimuli including behavioural responses (Tseng et al., 2011). Some people have difficulties regulating and organising their behavioural responses to sensory input in line with environmental demand (Miller et al., 2007). This has come to be known as 'sensory processing dysfunction' or 'sensory processing disorder' (SPD) (Goldsmith et al., 2016; Miller et al., 2007). While some children labelled with SPD may also meet the criteria for other psychiatric disorders it is also seen in children without these additional diagnoses (Goldsmith et al., 2016). People with sensory processing needs can demonstrate unusual responses to sensory stimuli such as over- or under-responsivity in some or all sensory systems including tactile, auditory, visual, olfactory, proprioceptive, and vestibular systems (Kandel et al., 2000; Reeves, 2001; Tseng et al., 2011). This can in turn affect development and 'functional abilities' in cognitive, behavioural, emotional, and motor domains (Kandel et al., 2000; Shepherd, 1994). According to Dunn's (1997) sensory processing model there are four 'dysfunctional' sensory processing patterns: low registration; sensation seeking; sensation avoiding; and sensory sensitivity. These can be categorised into over- or under-responsiveness, and passive or active behavioural strategies (see table 1). Sensory processing needs are surprisingly common with conservative estimates suggesting 5% of the hearing, non-clinical paediatric population may experience severe under- or over-responsiveness (Miller et al., 2007). Estimates for sensory processing needs in typically-developing, hearing children in clinical settings range from 5% to 10% (Ayres, 1989).

Table 1. Dunn's Sensory Processing Model

	Passive	**Active**
Under - responsive	***Low Registration*** – high sensory thresholds, passive behaviour strategy. Fail to detect stimuli others notice. Seen as withdrawing/inattentive.	***Sensation Seeking*** – high sensory thresholds, active behaviour strategy. Gain pleasure from rich sensory environment. Can be considered exuberant or distractible.
Over - responsive	***Sensory Sensitivity*** –low sensory thresholds, passive behaviour strategy. Discomfort with sensation. May be seen as precise or picky by others.	***Sensation Avoiding*** –low sensory thresholds, active behaviour strategy. Engage in behaviour limiting exposure to stimuli. Introspective /reclusive.

Children with sensory processing dysfunction can show decreased social skills and less participation in joint play, lower levels of self-confidence, self-esteem, and academic achievement, behavioural difficulties, diminished or delayed fine, gross, and sensorimotor skill development, and higher rates of anxiety and depression (Ashburner et al., 2008; Edgington et al., 2016; Parham & Mailloux, 2001). For children with sensory processing needs school and home environments can contain physical and social stimuli that frequently cause them significant levels of distress (Bundy, 2002; Burleigh et al., 2002). The fear, anxiety, or discomfort that may accompany these everyday situations can significantly disrupt daily routines (Bundy, 2002; Burleigh et al., 2002; Parham & Mailloux, 2001). Estimates of SPD in the adult, hearing, non-clinical population may well be similar to that of children (Engel-Yeger & Dunn, 2011). Adults who are over-responsive to environmental stimuli appear to experience everyday life differently from other adults, describing their daily experiences as irritating, overwhelming, disorganising, and distracting (Engel-Yeger & Dunn, 2011). They also report spending a great deal of time trying to cope with their responses to environmental stimuli; a situation that leaves them feeling exhausted and frequently isolated (Kinnealey et al., 1995; Oliver, 1990). This isolation can impact upon the individual's ability to fully participate and engage in the usual range of everyday occupations (Kinnealey et al., 1995; Pfeiffer, 2002). SPD has also been linked to mental health issues such as anxiety, depression, other social–emotional concerns, greater reactivity of the autonomic nervous system, and the employment of behavioural coping strategies in hearing, adult populations (see Engel-Yeger & Dunn, 2011 for a review). Sensory processing needs have also been found to correlate with other known risk factors for mental ill health including poorer social skills, social isolation, impaired self-care skills, and limitations in leisure activities and occupational choice (Pfeiffer et al., 2005; Kinnealey et al., 2011). For some people sensory processing needs can have a lifelong impact whereas for others these needs decline with age (Pfeiffer; 2002).

Sensory Processing Disorder: A Critical Realist Perspective.

SPD is not currently recognised in the Diagnostic and Statistical Manual of Mental Disorders Fifth Edition (DSM-5) or The World Health Organisation's International Statistical Classification of Diseases and Related Health Problems (10^{th} Edition) (Borkowska, 2017). Furthermore, symptoms associated with SPD have a large overlap with other psychiatric diagnoses (Borkowska, 2017). Currently, it is a source of controversy as to whether SPD represents a distinct set of symptoms or if it would best be thought of as part of the clinical picture of other disorders (e.g. Autism Spectrum Disorder (ASD) or Attention Deficit Hyperactivity Disorder (ADHD) (Borkowska, 2017)). This research was undertaken from the position of Critical Realism. This position advocates that something of the world can be known, but takes a critical, cautious approach to interpretation of causality and meaning. Like all psychiatric disorders SPD must be contextualised in the society in which it was developed. Other epistemological positions such as Social Constructionism would likely undertake a thorough deconstruction of the term "SPD", for example asking: 'What are the implications, motivations, and meanings behind labelling a child as having 'SPD' when they are unable, or unwilling, to endure an educational system designed in the Industrial Revolution to train 'working-class' children for a life of factory work?' (Schrager, 2018). In the current study terms such as ASD, ADHD, and SPD are held loosely, and a critical stance is kept regarding the localisation and pathologisation of different ways of being. If it is accepted that at least 5-10% of children (in the western world) have 'severe' responses to sensory stimuli (Ayres, 1989; Miller et al., 2007) can we really consider these responses 'abnormal'? Within the current work it is accepted that human beings interact with the world through mediums such as sound, taste, touch, and smell. It is also accepted that, at times, these interactions can coincide with physical and psychological distress and the likelihood of difficult experiences related to sensory processing appears higher for some groups of children compared to others.

Sensory Processing in Specific Paediatric Populations.

The causal mechanisms associated with sensory processing needs are unknown, with genetic and familial factors, maternal stress during pregnancy, jaundice, and allergies all suggested as risk factors (Ghanizadeh, 2011). Nonetheless, it is generally accepted that certain paediatric populations have significantly higher levels of sensory processing needs than the general population. These ideas are based on a growing evidence base consisting of qualitative works, small quantitative cross-sectional studies, longitudinal research, and meta-analyses. Amongst others, populations with higher levels of sensory processing needs include children with diagnoses of ASD and ADHD (Dunn, 2006; Tomchek & Dunn, 2007). However, it must also be acknowledged that patterns of behaviour associated with sensory processing needs among children with neurodevelopmental diagnoses are reflected in the general populations at large, and it is thought to be the frequency or intensity of certain behaviours that differentiate groups rather than the presence or absence of them (Ermer & Dunn, 1998). A full review of literature pertaining to sensory processing among children with diagnoses of ASD and ADHD lies outside the scope of the current project; however, brief summaries are offered to contextualise the current work.

Children with a diagnosis of ASD.

Sensory processing needs among children with a diagnosis of ASD have been well documented with estimates of sensory processing difficulties among this population as high as 90–95% (see Tomchek & Dunn (2007) for a review). Evidence for differing patterns of sensory processing among people with a diagnosis of ASD has been drawn from cross-sectional studies using quantitative measures and parent-reports (Rogers et al., 2003), small longitudinal studies (McCormick et al., 2016), qualitative work (Jones et al., 2003), and meta-analyses (Ben-Sasson et al., 2009; Lim et al., 2017). Significant correlations between anxiety and depression and sensory processing needs have also been identified among people with a diagnosis of ASD (Pfeiffer et al., 2005; Jones, Quigney, & Huws, 2009 Edgington, Hill, & Pellicano, 2016). Today the DSM-5 includes the presence of sensory processing difficulties as part of the diagnostic criteria for ASD (American Psychiatric Association, 2013). As such children with this diagnosis are able to access interventions designed to support and mitigate any emotional, psychological, behavioural, occupational, and educational impacts of their sensory experiences (Arbesman & Lieberman, 2010; Ashburner et al., 2008; Health Improvement Scotland, 2016; National Institute for Health and Care Excellence, 2017). Sensory processing among children with a diagnosis of ASD has been so highly studied that there are specific norms for this population available for clinical and research activities (Dunn, 2006).

Children with a diagnosis of ADHD.

Sensory difficulties in children with a diagnosis of ADHD have been analysed using behavioural and neurophysiology measures (Shimizu et al., 2014). While the majority of studies have been limited by small sample sizes (N = 24 to 104) evidence suggests that sensory processing needs among this group of children are significantly more common than in the ‘typically’ developing population (Ghanizadeh, 2011). Greater sensory processing needs among children with a diagnosis of ADHD have also been found to correlate with increased anxiety and higher rates of diagnosis for “oppositional defiant disorder” (Ghanizadeh, 2010). Dunn and Bennett (2002) suggested children with a diagnosis of ADHD may not receive and process sensory information in the same way as their peers, leading to difficulty producing appropriate responses including motor responses, activity levels, and behavioural responses, and creating barriers to learning, organisation, and engagement in leisure activities (Engel-Yeger & Ziv-On, 2011; Mulligan, 1996). Evidence also supports quantitatively different sensory processing profiles for children with a diagnosis of ADHD compared to those with a diagnosis of ASD or pervasive developmental disorder (PDD) and typically developing children (Cheung & Siu, 2009; Dunn, 2006). Similar to children with a diagnosis of ASD sensory processing norms are also available for children with a diagnosis of ADHD (Dunn, 2006).

Other Groups of Children.

Sensory processing needs have been investigated in several other groups of children. This includes children born prematurely (e.g. Crozier et al., 2015), children with disrupted attachment (Whitcomb et al., 2015), children with a diagnosis of Tourette's Syndrome (e.g. Ludlow & Wilkins, 2016), and children with a diagnosis of Specific Language Impairment (SLI) (Van der Linde et al., 2013). In their study Whitcomb et al. (2015) assessed 68 children (3–6 years) using the Short Sensory Profile (SSP), a shortened version of the 'gold standard' Sensory Profile Caregiver Questionnaire (SPCQ), and conducted behavioural observations in the home to assess attachment quality. The results pointed to a modest correlation between attachment and sensory processing suggesting children with an insecure attachment style may also struggle with interpreting and responding to sensory stimulation from the environment. Alternatively, it may also suggest that children who have atypical responses to sensory information may have difficulty forming a healthy attachment to their primary caregivers. Crozier et al. (2015) also used the SSP in their retrospective exploration of sensory processing in a cohort of 160 four year old children born prior to 32 weeks gestation. Almost half the cohort (46%) exhibited atypical sensory processing patterns. Van der Linde et al. (2013) also found higher levels of atypical sensory processing among children with a diagnosis of SLI, a communication disorder that interferes with the development of language in children who have no hearing loss or intellectual disabilities. Van der Linde et al. (2013) used the full SPCQ with a small sample (N = 21) of children and compared these results with norms for typically developing children, and children with diagnoses of ASD or ADHD. The results demonstrated differing sensory processing patterns among children with SIL compared to other groups. Hulslander et al. (2004) have proposed a possible association between speech and language disorders and sensory processing difficulties in general, drawing on the view of speech and language as end products of sensory integration (Ayres, 1989). With children born prematurely also exhibiting atypical language development (Rand & Lahav, 2014; Crozier et al., 2015) and language acquisition linked with attachment (van IJzendoorn et al., 1995) we may begin to wonder at the impact of different experiences of language on sensory integration and therefore sensory processing needs.

Intervention for Sensory Processing Needs.

Understanding a child's experiences of sensory stimuli can help families and professionals understand a child's emotional and psychological distress when they are faced with experiences their peers seem to easily tolerate (Ermer & Dunn, 1998). As such, developing a contextually relevant understanding of the impact of sensory experiences in everyday environments is of paramount importance (Ermer & Dunn, 1998). For young children the 'gold standard' in such assessment is the Sensory Profile Caregiver Questionnaire (SPCQ) (Dunn, 2006; Ohl et al., 2012; Van der Linde et al., 2013) . The SPCQ is a reliable and validated measure widely used in clinical assessment, as an outcome measure, and as a research tool. It offers comparative norms for neurotypical and atypical paediatric populations and has been translated and validated for use round the world (Benjamin et al., 2014; Dunn, 2006; Ohl et al., 2012). The SPCQ offers therapists insight into the sensory processing experiences of a young person allowing them to determine a child's sensory preferences and helping to guide therapeutic intervention (Dunn, 2006). This is of crucial importance considering a growing body of research suggesting that once sensory needs have been identified successful interventions can be offered. One such intervention is Sensory Integration Therapy, tailored programmes of play-based activities such as using therapy balls and swings and single sensory strategies (e.g. weighted vests) which aim to help a child adapt their responses to sensory stimuli (Pollock, 2009). To date there is limited evidence for the effectiveness of such interventions (Borkowska, 2017; Edgington et al., 2016; Health Improvement Scotland, 2016; Lang et al., 2012; Vargas & Camilli, 2000). Occupational Therapists can also employ other forms of interventions which focus on working with the children, parents, and educators to adapt the environment a child is exposed to (Pollock, 2009). This may include modifying clothing, changing room temperatures or configurations, adjusting noise or light levels, or adjusting demands (Pollock, 2009). These approaches are designed to enable children to function to the best of their ability as opposed to trying to change their underlying neurological functioning (Pollock, 2009). There is also limited evidence suggesting psychoeducational (Vargas & Camilli, 2000) and Cognitive Behavioural Therapy interventions (Edgington et al., 2016) may also have some utility in supporting some young people with sensory processing needs. To date, there have been no studies exploring clinically based sensory processing assessments or interventions with d/Deaf children. Moreover, there seems to be an active screening out of children with comorbid deafness, with hearing loss listed as one of the exclusion criterion in a recent systematic review on the effectiveness of interventions for young people with sensory processing needs (Arbesman & Lieberman, 2010)

Introduction to d/Deafness

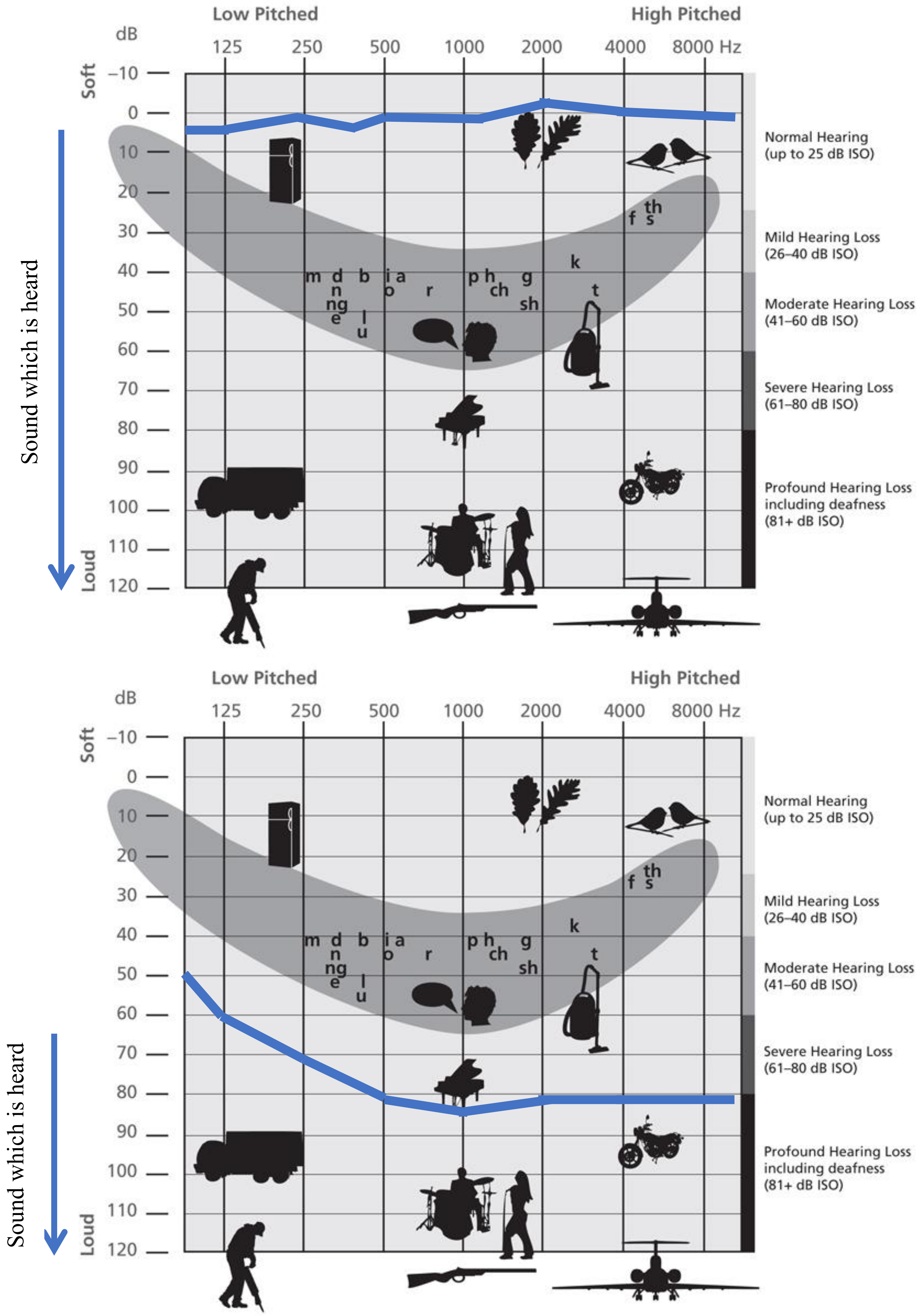
Measuring deafness

Hearing loss can be separated into conductive and sensorineural hearing loss. Conductive hearing loss occurs when a blockage or damage to the ear prevents sound from passing from the outer to the inner ear (e.g. ear wax, glue ear, perforated eardrums). Sensorineural hearing loss is caused by damage to hair cells inside the inner ear and/or damage to the hearing nerve. This can be caused by genetic factors, infections such as meningitis, and physical trauma. Presbycusis, (age-related hearing loss) and noise-induced hearing loss both fall into the sensorineural hearing loss category. Sensorineural hearing loss can make it more difficult to hear quiet sounds and/or reduces the quality of any sound that is heard. When diagnosing deafness, audiologists measure hearing levels using two key indictors. These are audible volume measured in decibels (dB) and audible pitch frequency measured in hertz (Hz). Medically deafness is categorised into mild, moderate, severe, and profound deafness. A useful way to understand how deafness impacts upon hearing is by considering an audiogram chart with a 'speech banana' superimposed on to it. An audiogram chart show where common noise occurs on the audiological spectrum while the speech banana, so called because of its shape, shows the level and frequency of speech sounds in language (see table 2 and figure 1). Together these can indication an individual's residual level of hearing.

Table 2. Degrees of Hearing Loss (based on Clark, 1981)

Category of loss	Range of loss (dB)	Qualitative Description of Hearing (Hz)
Mild	26 to 40	May hear speech but soft sounds (e.g. whispers or consonants at the end of words such as 'shoes' or 'fish') are hard to hear.
Moderate	41 to 70	May hear another person speaking at a normal level but have difficulty understanding what they are saying. Might hear the vowels within a sentence but not the consonants. Understanding a spoken sentence is almost impossible.
Severe	71 to 90	Hears little to nothing at a normal spoken level and only some loud sounds. Very loud sounds, such as a car horn, are not startling in the same way they are to a normally hearing person.
Profound	91+	Does not hear speech, only very loud sounds / only feels vibrations of the loudest of sounds (e.g. a jet engine).

Figure 1. Examples of audiogram chart with speech banana for typically hearing and moderate to severely deaf person



deaf or Deaf?

The word *deaf* with a lowercase 'd' is often used to describe a person who is medically categorised as having impaired levels of hearing (Woodward, 1972). Usually deaf people subscribe to this view and consider themselves to be hearing impaired or disabled. They may have become deaf late in life, but not always, and typically use spoken or written language to communicate. Often deaf people develop or retain an identity in line with the (hearing) majority group into which they have been socialised (Woodward, 1972). In contrast to the medical view of deafness, people with a Deaf cultural identity are often referred to as "*Deaf*", with a capital "*D*" (Woodward, 1972). Deaf people are usually born deaf or become so prelingually (Glickman, 2007). When referring to both deaf and Deaf people at once it is common to use the phrase d/Deaf (Woodward, 1972). Deaf cultures have their own social norms, values, beliefs, and behaviour, their own art, literary traditions, and history independent of the hearing majority. A key feature of Deaf cultures and identification with a Deaf community is the use of a signed language as a first or preferred language (Glickman, 2007). This makes Deaf communities both a linguistic and cultural minority (Glickman, 2007). The signed language of the UK Deaf community is British Sign Language (BSL).

The Deaf Community in the UK: Historical and Modern Contexts.

The history of BSL and the UK Deaf community is deep and rich, but it is also marked by substantial levels of prejudice, discrimination, and oppression by the hearing majority. This is evident in historic terms such as "Deaf and Dumb", ableist social attitudes and norms, marginalisation, and exclusion of d/Deaf from the workplace and social life, and governmental policies which delegitimise and repress BSL. There is solid evidence of signing by d/Deaf people in Britain as early as in the 16th century, with most scholars agreeing that signing predates these records (UCL, 2020). However, it wasn't until 2003, after years of activism by the Deaf community and an academic work 'proving' BSL to be a complete, independent language (published in 1974) that the British Government recognised BSL as a minority language (SeeHear, 2010; UCL, 2020). Further back, the 1880 Second International Congress on Education of the Deaf held in Milan and commonly referred to as the Milan Conference declared sign language inferior to Oralism, a method of teaching d/Deaf children reliant on speech and lip-reading. This led to widespread bans on signed languages in Deaf schools throughout the world including in the UK. The result of this saw Deaf teachers unemployed and generations of d/Deaf children whose 'education' was years of attempts to 'give them' speech (SeeHear, 2012a, 2012b). It wasn't until the 1970's that d/Deaf education shifted away from the covenants laid down by the Milan conference and not until 2010 that the 21st International Congress passed a resolution rejecting the motions passed in Milan (UCL, 2020). Today like other minority groups Deaf communities and d/Deaf people continue to experience prejudice, discrimination, and disempowerment (Glickman, 1996). In the UK recent examples of this include caps to Access to Work (AtW) grants. AtW is a government scheme designed to support ‘disabled’ people in the workplace. An estimated 90% of those affected by the AtW caps were Deaf people who relied on these funds to pay for BSL interpreters without whom they could not continue to work (Clare, 2017). Another example is the on-going refusal of the British Government to sanction a BSL GCSE. The Government’s 2017 refusal statement, which was subsequently edited following significant backlash for Deaf activists, stated “*…the national curriculum...for languages contain a number of requirements that could not be met through BSL; for example… the requirement to describe [things]…in writing*” (UK Government, 2017). This requirement privileges spoken languages over visual ones as the written word is based on the spoken one (Chafe & Tannen, 1987). In the spring of 2020 Deaf campaigners began legal proceedings against the British Government over the absence of a BSL interpreter at the Prime Minister’s daily Coronavirus (Covid-19) briefings. This absence left Deaf people among who there are low levels of literacy arising from inadequacies in the UK’s educational system (Glickman, 2007) struggling to access public health information through English language subtitles (Rose, 2020).

Mental Health.

Around the world d/Deaf people achieve lower levels of education, experience lower socio-economic status and levels of employment, suffer increased rates of sexual, domestic, and substance abuse, and experience significant barriers in accessing health and social care (Conama & Grehan, 2001; Conroy, 2006; Farrant & Mager, 2017; Guthmann & Graham III, 2005; Haualand & Allen, 2012; Landsberger & Diaz, 2010; SignHealth, 2014, 2016). Globally there is a strong link between d/Deafness and mental health difficulties (Department of Health, 2005) yet to date no major epidemiological work exploring incidence rates of specific mental illnesses in d/Deaf populations has been undertaken (Fellinger, Holzinger, & Pollard, 2012). Current literatures suggests d/Deaf people mostly experience common mental health difficulties such as anxiety and depression; however, they do so at far greater rates during childhood, as adults and older adults, and in forensic settings (Werngren-Elgström et al., 2003; Department of Health, 2005; Landsberger & Diaz, 2010;Fellinger et al., 2012;

McCulloch, 2012). There are also concerns that d/Deaf people in contact with services are more vulnerable to being misdiagnosed, labelled mentally ill when no diagnosable disorder is present, subjected to a restricted range of diagnoses, and deprived of treatment choice. There are also additional concerns that residual categories such as "not otherwise specified" are applied differently to d/Deaf patients and evidence that d/Deaf people being detained longer within forensic settings (Steinberg et al., 1998; Young et al., 2001; Young, Howarth, Ridgeway, & Monteiro, 2001; Black & Glickman, 2006; Landsberger & Diaz, 2010; Cole & Magis, 2011; Fellinger et al., 2012). d/Deaf people are vulnerable to the same mental health risk factors as their hearing peers (e.g. lower socioeconomic status, parental mental health difficulties, substance misuse, bullying etc.), but they also face additional challenges (Moreno & Glenn, 2018). Approximately 90% of d/Deaf children are born to hearing parents (Mitchell & Karchmer, 2004). This can leave parents, even those with ample resources, unable to provide their child with access to language. To illustrate this, let us consider the fictional case of 'Annie'. Annie 'failed' her new-born screening test. This meant her parents learnt she was profoundly deaf within a week of her birth (not always the case with diagnosis for some children as late as their teenage years). Annie's parents felt no sense of loss or anxiety and there were no disruptions in attachment due to her deafness. They acted immediately, signing up for a 10-week Level 1 BSL evening course at a cost of £500[2] per person. By the time Annie was six months old both her parents could sign the alphabet and numbers, say "hello", and use single signs to describe the weather, name common animals, items of food and drink, and rooms in the house. Their Level 2 course (£400 per person, 15 weeks[2]) taught Annie's parents to construct simple sentences in BSL and expanded their vocabulary to topics such as work life, travel, and education. At Level 3 (£1,137 per person, 66 weeks[3]) the parents learnt to create more complex sentences and acquired vocabulary on politics and health. They were quick learners, always remembered to sign around Annie, never grew frustrated or tired, and always had the time and resources for classes. Annie's grandparents, aunts, and uncles also signed up for these BSL classes. Annie's is an idyllic, unrealistic example of a family's response to a child's deafness but even in her case we see her parents were only able to start exposing her to fluent language use at two years old. For late BSL learners, native-like fluency is generally not achieved until they have completed Level 6. Most parents do not

[2]*Costs, duration, and syllabus from Sign Language Course in London, an accredited BSL centre. https://www.signlanguagecourses.co.uk/*

[3]*Costs, duration, and syllabus from Remark! in London, an accredited BSL centre https://remark.uk.com/bsl-level-3/*

move beyond BSL Level 1, with Level 3-6 courses primarily aimed at organisations supporting d/Deaf people and those seeking a career as a professional interpreter. The use of spoken language by the majority of the population places d/Deaf children at a further disadvantage as they cannot access the opportunities for incidental learning in the way their hearing peers do. In illustration by anecdote, my Deaf sister and brother-in-law were often left puzzled when my hearing niece came out with new words or phrases, unsure where she had picked these up. As a family we were generally able to trace these back to overheard conversations or on one memorable occasion a film that her father had not realised was unmuted. d/Deaf children cannot access learning-by-osmosis the same way hearing children do. This is one reason d/Deaf children sometimes present with significant gaps in language, knowledge, and their understanding of social norms and expectations. Unless explicitly, directly explained in a way they can absorb they simply miss out on some things other children can just pick up on. As Annie's case alludes to, delayed language acquisition is common among d/Deaf children (Moreno & Glenn, 2018). This in turn results in early social isolation which, with so much of development socially mediated, places d/Deaf children at a higher risk of developing mental health problems (Moreno & Glenn, 2018). d/Deaf children, particularly those with limited communication skills, may then exhibit 'externalizing' presentations that others interpret as disruptive, aggressive, or anti-social rather than as indications of psychological or emotional distress (Moreno & Glenn, 2018). As such, they may not be referred to mental health services until much later in life (Moreno & Glenn, 2018). Compounding this, d/Deaf children like d/Deaf adults experience significant difficulties accessing mainstream services where staff lack the training, expertise, or knowledge to meet their needs (NHS Commissioning Board, 2013; Szarkowski et al., 2014). It was the recognition of these factors which led to the creation of small, highly in demand, specialist mental health services for d/Deaf children and young people in the UK (NHS Commissioning Board, 2013). The need for specialist services partly relates to d/Deaf children's unique communication needs. It also reflects the increased likelihood they will experience other risk factors associated with mental health difficulties. More so than their hearing peers, d/Deaf children present to services with additional physical, neurological, or developmental needs, including increased rates of physical ill-health, attachment difficulties, and higher rates of neurodevelopmental diagnosis such as ASD or ADHD (NHS Commissioning Board, 2013; Szarkowski et al., 2014; Tomchek & Dunn, 2007). d/Deaf people are also considerably more likely to experience trauma and abuse during childhood (Landsberger & Diaz, 2010). d/Deaf children and young people are at a high risk of mental health difficulties which are often part of highly complex presentations, yet the evidence base related to these children's development and mental health remains particularly sparse (Moreno & Glenn, 2018).

d/Deafness and Sensory Processing

Traditionally two opposing hypotheses relating to the impact of deprivation in one sensory modality on the remaining senses have been proposed. These are the Perceptual Deficit Hypothesis and the Sensory Compensation Hypothesis (Pavani & Bottari, 2012). The Perceptual Deficit Hypothesis states that a 'deficit' in one sensory system will negatively affect the development and organisation of other sensory systems (Pavani & Bottari, 2012). This hypothesis would predict poorer performance in all sensory modalities among d/Deaf people compared to age-matched hearing controls. In contrast, the Sensory Compensation Hypothesis proposes deficits in one sensory system will lead to increased sensitivity in other systems, compensating for the loss of one channel of input (Pavani & Bottari, 2012). This hypothesis suggests areas of the brain traditionally associated with the impaired sense may develop the ability to process perceptual inputs from other sensory systems (functional reallocation) or that the other sensory systems will acquire enhanced functional and processing capabilities (remaining senses hypertrophy) (Pavani & Bottari, 2012). If we applied these hypotheses to d/Deaf people we might expect higher rates of under or over-responsiveness to sensory stimuli depending on which hypothesis was proven. Despite 30 years of systematic research (largely focusing on visual abilities rather than sensory processing in general) the debate over whether perceptual functioning in d/Deaf individuals is under or overdeveloped remains unsettled (Pavani & Bottari, 2012). Research evidence is mixed; split between suggestions of comparable performance between d/Deaf and hearing people, and evidence of differential performance in the direction of deficits in abilities and the direction of supranormal abilities in d/Deaf participants (for a full summary see Pavani & Bottari (2012)). Since the 1980s a significant portion of sensory processing work with d/Deaf people has focused on recording neural responses and comparing these with hearing people. Today there is a growing acknowledgement that the absence of behavioural observations related to sensory processing among d/Deaf people means even the most striking neurological differences will not be able to unravel the debate round the Perceptual Deficit and Sensory Compensation Hypotheses (Pavani & Bottari, 2012). The emphasis on the neurological has also come at the expense of exploring meaningful differences related to sensory processing in the lives of d/Deaf people, any difficulties that may arise from these, and the development of effective, relevant therapeutic interventions. d/Deaf people have different experiences from hearing people in childhood, through adolescence, and as adults. As such, diagnostic thresholds and interventions related to sensory processing relevant for any hearing populations may not be relevant to d/Deaf children and young people. Furthermore, d/Deaf children and young people are at an increased risk of life events and experiences which have been linked with increased likelihood of sensory processing needs. For example, there are increased rates of diagnosis for both ASD and ADHD among d/Deaf children although clinically there are considerable challenges related to making these diagnoses for d/Deaf children due to the similar nature of difficulties that can arise as consequences of deafness and those associated with ASD and ADHD (Kelly et al., 1993; Szarkowski et al., 2014). As such, missed and misdiagnosis of ASD and ADHD are commonplace (Szarkowski et al., 2014). Missed diagnosis is thought to be linked to an exclusive focus on deafness limiting understanding of difficulties as being solely linked to challenges related to being deaf. In the case of missed diagnosis d/Deaf children and their families subsequently miss out on beneficial support and early intervention which could significantly improve their quality of life (Szarkowski et al., 2014). In contrast, misdiagnosis is thought to result from the misinterpretations of social-communication difficulties and behaviour rooted in language deprivation (Kelly et al., 1993; Szarkowski et al., 2014). As such, when considering sensory processing among d/Deaf children it is important to hold in mind profiles found among children with a diagnosis of ASD or ADHD as well as those associated with typically developing children. There is also evidence of sensory processing needs among children born prematurely. Like d/Deaf children, children born prematurely also exhibit atypical language development. This is proposed as a potential consequence of limited access to language during prolonged stays in Neonatal Intensive Care Units (Rand & Lahav, 2014; Crozier et al., 2015). Considering this, and with a possible association between speech and language disorders and sensory processing difficulties in general (Ayres, 1989; Hulslander et al., 2004), we might also wonder about the impact of limited access to language on sensory integration. Premature birth is also a risk factor associated with both deafness and disruptions in attachment (Bielecki et al., 2011; Davis et al., 1983). Whitcomb et al. (2015) found a significant proportion of the variance in sensory processing scores (measured by the SSP) could be explained by the security of a child's attachment suggesting a relationship between attachment style and sensory processing needs. There is an acknowledged link between disrupted attachment and a child's deafness in hearing families that is not mirrored in Deaf families (Meadow et al., 1983; Hughes, 2012). However, as 90% of d/Deaf children are born to hearing parents (Mitchell & Karchmer, 2004) the link between attachment and deafness, and attachment and sensory processing needs is an important one to hold in mind. There is also considerable academic research pointing to differences in sensory processing among people who are d/Deaf, and links between auditory deprivation and functional plastic changes in the central nervous system which plays a key role in sensory processing (Suarez et al., 2007). d/Deaf people are also known to be at higher risk of developing mental health difficulties. As such, the impact and meaning of any difficulties with sensory processing needs may be of greater clinical significance for d/Deaf children and young people when compared with their hearing peers. Despite known differences in sensory processing systems among d/Deaf people, and links between sensory processing and attachment and language, and neurodevelopmental diagnoses occurring at increased rates among d/Deaf children sensory processing among this population have not yet been explored clinically. Meanwhile research and interventions related to sensory processing, and its impact on psychological distress and activities of daily living among other paediatric populations are well underway.

The Danger of Paving with Good Intention

There is growing evidence that sensory processing needs can have a lifelong, significant, negative impact on wellbeing but that professional support and interventions can help mitigate these. However, SPD is not currently recognised by the DSM-5 or ICD-10 and there is a large overlap of symptomatology between this and other psychiatric diagnoses. Sensory processing needs are not uncommon among the general paediatric population however there is evidence that challenges related to attending to, receiving, using, and responding to sensory stimuli are more likely in some cases than others (e.g. premature birth, attachment difficulties, and specific clinical diagnoses). The concept of SPD has arisen in particular time in Western society; a time when the medical-scientific model is the dominant, where there are particular, significant demands and expectations for children and young people, novel pressures in school, home, and community systems (particularly for d/Deaf children), and greater levels and intensity of sensory stimulation than ever before in human history. Within this work it has been accepted that people experience sensory stimuli, that these experiences are linked to physical and psychological processes which are intrapersonal and internal, and that these experiences have the potential to cause discomfort and distress. However, we must also recognise that labelling responses to sensory stimuli as ‘typical’ or ‘atypical’ is a system of categorisation that is based on sociocultural constructs: similar to categorisations in other aspects of the human experience such as intellectual functioning.

Therefore, it is also important to take a critical view of 'SPD' and to hold an external and interpersonal interpretation of behaviours associated with sensory processing in mind. Behaviour associated with sensory processing needs do not necessarily suggest a deficit or difficulty located within a child. Instead, these difficulties could be thought valid and appropriate responses to demands and restrictions in maladaptive environments created for children and young people by society. This shift in thinking necessitates a shift in clinical efforts away from teaching a child to tolerate or adapt to an intolerable environment, and towards the restructuring of society and the environments children are subjected to. This is particularly true in the case of d/Deaf children who are often placed under significant levels of demand to adapt to hearing environments. In the case of d/Deaf children, the same behaviours associated with sensory processing needs are also linked with language deprivation and sociocultural structures and attitudes which lead to experiences of prejudice, discrimination, isolation, and marginalisation. While not inevitable, or uniform in any way, the factors impact upon psychosocial development, family structure, attachment, access to education and academic outcomes, and experiences of health and social care including restricted access and limited choices, and differential rates and categories of diagnoses. By definition d/Deaf children experience at least one sensory input differently than other children and are also at a heightened risk of experiencing psychological distress due to the unique challenges they face within society. They are also at an increased risk of missed and misdiagnosis, resulting in less effective professional and social interventions and support. If efforts are not made to include d/Deaf young people in research, this will continue. If efforts are not made to understand more about the risk factors associated with psychological distress among d/Deaf young people, develop effective interventions aiming to improve wellbeing and quality of life for d/Deaf young people and to understand and meet the needs of d/Deaf children, this will continue. As such, there is a strong ethical argument for undertaking research related to mental wellbeing in d/Deaf young people, cautiously, carefully, and with due consideration to the complexity of any clinical applications of the results and the wider context and body of research in which any results are situated. Unfortunately, sensory processing is just one area where, to date, d/Deaf people have been unconsciously missed or deliberately excluded from thinking and research.

Chapter Summary

- For some young people organising and regulating behavioural responses to sensory input in line with environmental demand is challenging. Estimates suggest that between 5-10% of the hearing paediatric and adult non-clinical populations demonstrate severe under or over responses to sensory stimuli.

- Children with sensory processing needs show decreased social skills, experience lower levels of self-confidence, self-esteem, and academic success, and experience difficulties in activities of daily living. Sensory processing needs also correlate with higher rates of mental health difficulties and can have a lifelong impact.

- Interventions for sensory processing needs and their impact on psychological wellbeing and activities of daily living are available.

- Some groups of children are more likely to have sensory processing needs.

- d/Deaf people experience at least one sensory input (auditory stimuli) differently to the general population, with research suggesting differences in multiple sensory domains.

- There are links between deafness and certain risk factors associated with increased levels of sensory processing needs; however so far d/Deaf people have been excluded from thinking and research in this area.

- Globally there is a strong link between d/Deafness and mental health difficulties across the lifespan. d/Deaf children and young people are at a high risk of mental health difficulties than their hearing peers but the evidence base related to their needs is limited.

- Estimates of sensory processing needs among d/Deaf children are unknown. Clinical research relating to the impact of sensory processing on the daily lives and mental wellbeing of d/Deaf children has not yet been conducted.

The next chapter of this thesis will summarise current knowledge relating to sensory processing among d/Deaf people and explore links between sensory processing and mental health people among people who are d/Deaf. The rationale and aims for the current project are also outlined with later chapters outlining the method and results of the current study and contextualising these findings within existing research.

CHAPTER 2 - LITERATURE REVIEWS

"If I have seen a little further it is by standing on the shoulders of Giants" (Newton, 1676)

During the development of the current project a series of literature searches were conducted to gain a sense of the available literature and refine search terms (see Appendix 1). Initial search terms were created by the project team based on their knowledge of sensory processing and mental health in d/Deaf people and supplemented by keywords and terms generated by initial reviews of relevant work. Balancing a desire for comprehensiveness with the requirements and constraints of this thesis led to two reviews being undertaken. The first review was a scoping review; a type of review designed to outline gaps in a body of literature and serving to enhance future research (Arksey & O'Malley, 2005). The process of undertaking this review highlighted significant gaps in current knowledge relating to the impact of sensory processing on mental health in d/Deaf children. However, due to the scarcity of literature the review failed to adequately frame the need to understand sensory processing in d/Deaf children. Therefore, broader search terms were used to undertake a systematic review exploring literature on general differences in sensory processing among d/Deaf people across the lifespan. A systematic review aims to evaluate the existing literature related to a research question (Davis et al., 2009). In this chapter the broader systematic review is presented first to offer context for the scoping review and current project.

The Systematic Review: Sensory Processing Among d/Deaf People

The systematic review aimed to address the question: are there differences in sensory processing between d/Deaf and hearing people?

Search Strategy.

An electronic search of the Cochrane Database of Systematic Reviews, PubMed, and Scopus databases was carried out. Searches were carried out in November 2019. Boolean operators were used to combine the search terms, and search terms were truncated with the asterisk operator where appropriate (see table 3). Literature from 2009-2019 was searched using keyword, abstract, and title field searches. 596 papers were retrieved. During the initial screening, duplicates were removed, and titles and abstracts were screened. 553 papers were removed, and the remaining 43 texts were read in full and assessed using specific inclusion/exclusion criteria (see table 4). To provide the most comprehensive review of the literature the reference lists of articles were manually scanned for additional relevant papers.

In total 47 papers were selected for review (see figure 3 and Appendix 2). Of these papers 31 were related to visual processing, six to vestibular/balance abilities, four to motor skills, two to tactile processing, and one to olfactory. Three papers related to sensory processing disorder. Two papers in the visual domain were summaries of existing literature. The remaining papers were experimental designs comparing d/Deaf people with hearing, blind, or deafblind controls using quantitative methods. No relevant papers related to taste/oral processing or auditory processing were found. Overall sample size, range of degree of hearing loss, language use and fluency, auditory equipment use (e.g. none/hearing aids/cochlear implants), and aetiology of deafness (when given) varied considerably. Literature was reviewed, organised, and summarised by sensory modality (see Appendix 2 for full list of papers). Papers were screened for their comprehension in assessing both deafness and areas of sensory processing and their application to everyday living and mental health. Less attention was given to particular research methods or the assessment tools that were used. In May 2020, prior to submission of this thesis an additional literature search was undertaken. No new papers were generated.

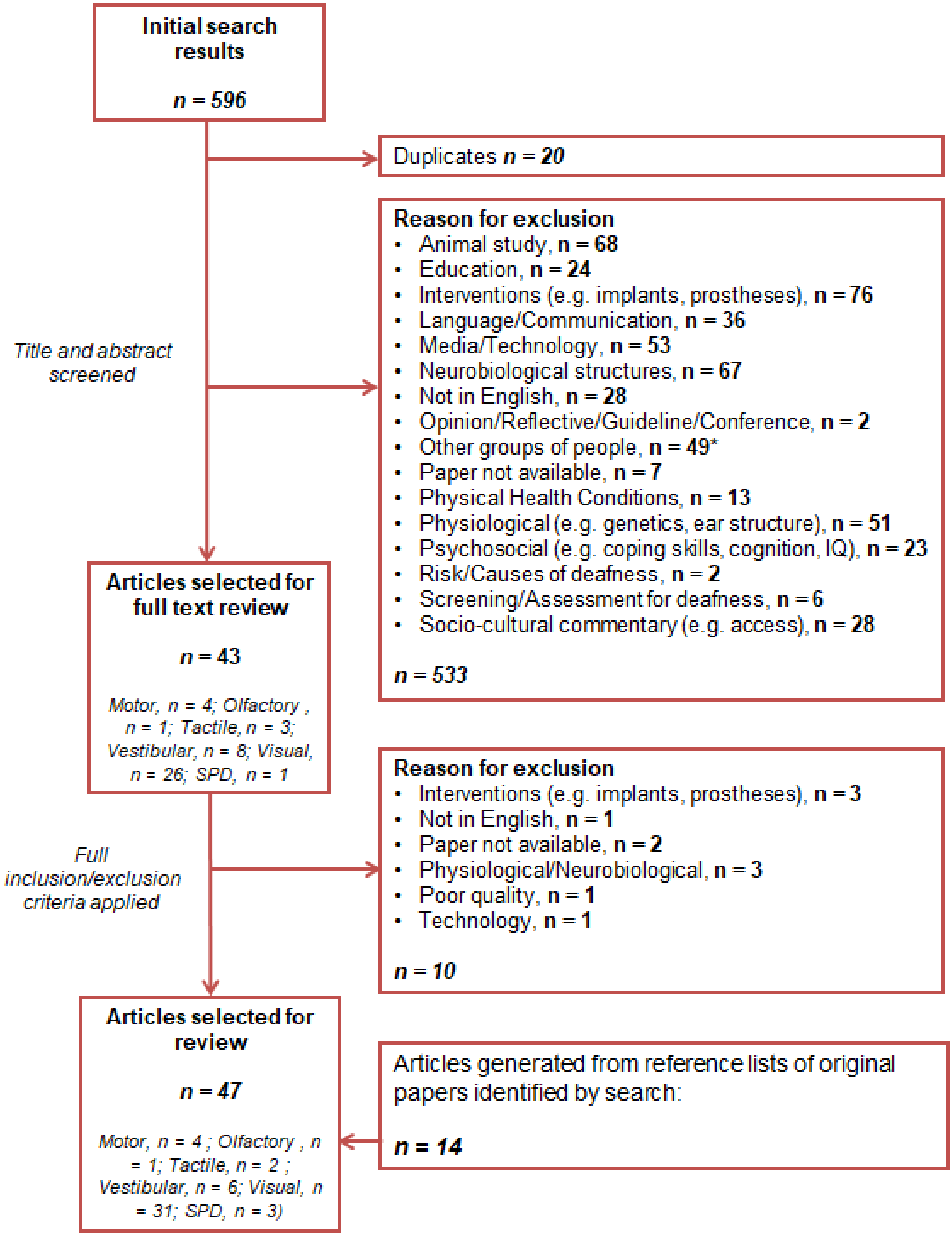
Table 3. Search Terms used for Systematic Review

Sensory Processing		d/Deaf
Sensory Sensory processing Sensory processing dysfunction	*AND*	Deaf*

Table 4. Systematic Review Inclusion and Exclusion Criteria

Inclusion	Exclusion
Pertains to d/Deaf people	Based on animal data
Sensory processing in any modality	Focused solely on physiological or neurological structures
Paper is available in English	Study focuses on other population
	Study focuses on physical or psychosocial interventions
	Literature solely concerned with linguistics or communication methods
	Solely concerning media/tech resources/developments
	Guidelines or conference notes
	Screening or measurement tool development or evaluations
	Socio-cultural commentary (reflections/reviews on access to education, mental health care or other public services)

Figure 2. Flow of Sensory Processing Review



*blind, n = 3; deafblind, n = 28; hearing, n = 4; deafened in later life, n = 8; ASD, n = 5; ID, n = 1

Findings.

Visual Processing.

Literature available on d/Deaf people's visual processing was considerable and over half of the papers originally identified were related to the visual sensory domain (see Appendix 2). Interest in this area dates back to the seventeenth century (Pavani & Bottari, 2012) but in the current review, restrained by time, resources, and the scope of the current project, only a 10-year period from 2009-2019 could be covered. Given the number of papers and the limited relevance an in-depth exploration of visual abilities in d/Deaf people would offer to this project, a broader, higher level summary of this area will be provided instead of an analysis critiquing individual papers. For those keen to explore this area, comprehensive summaries of this body of research and detailed reviews of meta-analyses can be found in Bavelier, Dye, & Hauser (2006) and more recently Alencar, Butler, & Lomber (2019). In brief, visual skills in d/Deaf people do appear to be altered when compared with hearing people but only in very specific ways and there is no evidence for general enhancement of visual skills due to the absence of auditory input (Bavelier et al., 2006) nor lowered visual abilities in adulthood (see Alencar et al. (2019) for more information). d/Deaf people do seem to exhibit supranormal abilities compared to hearing control in some areas such as an ability to detect motion in their peripheral vision, a lower threshold for detecting movement (Bavelier et al., 2006; Shiell et al., 2014), and better performance in visuomotor synchronisation tasks (Iversen et al., 2015). d/Deaf people also display differing lateralisation biases in the detection of visual stimuli, performing better when stimuli is presented in the right visual field whereas hearing controls demonstrate equivalence in performance for left and right visual fields or even a bias toward the left (Brozinsky & Bavelier, 2004). However, the right visual field advantage has also been seen among hearing sign language users and it is therefore possible that lateralisation differences are the result of exposure to, and use of, signed languages rather than hearing loss (Alencar et al., 2019). Of more direct relevance to the current study are findings which suggest d/Deaf children achieve lower scores on measures of visual perception compared to hearing controls until the age of approximately 10 years, similar to controls between 10 and 12 years, and better than controls from age 13 on (Alencar et al., 2019). Five to 10 year old d/Deaf children have also been found to be worse at detecting dim stimuli presented in the far periphery when compared to age-matched hearing controls, reaching equivalent performance at 11-12 years (Codina et al., 2011). 10-12 year old d/Deaf children have demonstrated equivalent performance to hearing children in the central visual field on brightness discrimination (Bross & Sauerwein, 1980), and facial recognition and orientation judgement (Parasnis et al., 1996). By age 13-15 years, d/Deaf children show enhanced performance relative to hearing controls and adults on peripheral visual tasks (Codina et al., 2011), visual object-matching tasks, and face-matching tasks with d/Deaf adolescents showing significantly better rates of correct answers, fewer mistakes, and greater overall accuracy (Megreya & Bindemann, 2017).

Balance and Motor Skills.

Foreword: vestibular disorders.

This review does not aim to summarise research into vestibular disorders among d/Deaf children, however it is important to briefly highlight this area of study before considering balance and motor processing. Vestibular disorders can lead to impairments of motor development and balance (Rine, 2009). These are an overlooked problem in paediatric populations in general (Rine, 2009) but d/Deaf children are at increased risk of these due to malformation of vestibular receptors which can occur in some forms of inner-ear deafness (Suarez et al., 2007). There are also suggestions of peripheral vestibular dysfunction and delayed postural control in some types of congenital or early-acquired deafness (e.g. inner-ear malformations, meningitis, viral labyrinthitis) and some forms of hereditary deafness (Suarez et al., 2007). In fact it is estimated that 30–95% of children with hearing loss experience some kind of vestibular dysfunction, with dysfunction increasing with degree of hearing loss (De Kegel et al., 2010; del Pino et al., 2011; Selz et al., 1996). Vestibular dysfunction can interfere with many areas of children's development, including static and dynamic balance reactions, coordination, and the speed of performed movements (Chilosi et al., 2010). As such, we would expect d/Deaf children to show increased difficulty with both balance and motor skills. Despite some limitations research evidence in both of these areas seems to support this expectation; however, it also suggests evidence of differing motor and balance performance among d/Deaf children in the absence of any vestibular abnormalities (e.g. Crowe & Horak, 1988).

Balance.

In a test of single-limb standing balance with 54 sets of matched-pairs An, Yi, Jeon, & Park (2009) found that severe-profoundly d/Deaf children (hearing loss, ≥70 dB; see table 1) aged four to 14 years of age performed worse than hearing controls. However, lateralisation of deafness was not specified, language use and use of hearing equipment was not controlled for, and aetiology of hearing loss was not established. This is important information in the interpretation of any results as it is unclear whether factors other than hearing loss may have contributed to the results. For example, Selz et al. (1996) found significant differences in balance performance between d/Deaf children aged 8-17 years with non-syndromic hereditary deafness (n = 5) and acquired deafness (n = 5) due to meningitis, with children with acquired deafness performing significantly worse than children with hereditary deafness in some tests. However, in Selz et al.'s (1996) study all of the children exhibited normal walking gaits and were active participants in 'competitive sport events' at their residential school, although details of what is meant by this are lacking. This suggests any real-world impact of difference in balance performance scores may be limited. In a more recent study 228 children (65 d/Deaf, 163 hearing) aged between eight and 17 years were assessed on static balance with the children asked to stand still on one leg under differing conditions (e.g. eyes open or closed, standing on different materials (Walicka-Cupryś et al., 2014)). In this study d/Deaf children were found to have superior balance compared to their hearing peers. However, there are severe limitations to this study. Of the d/Deaf children, 25 children were born d/Deaf and 40 became so later in their lives. Aetiology and lateralisation of deafness is not provided. The children are described as having a level of deafness ≤90 dB however the lower limit is not given. As such, these children must be thought of as experiencing mild to severe deafness, both unilaterally and bilaterally, which represents a considerable range of experience. In addition, children with an intellectual disability and any comorbid illnesses were excluded, including, presumably, any child with a known vestibular dysfunction, limiting generalisability in a population with high levels of comorbid diagnoses. Language use is once again not considered. In the most recent paper identified in the literature search Ebrahimi, Movallali, Jamshidi, Rahgozar, & Haghgoo (2017) also support statistically significantly lower levels of postural control in d/Deaf children between the ages of seven and 12 compared with hearing controls (n = *30* and 49 respectively). The d/Deaf children in this study were selected based on a diagnosis of profound sensorineural hearing loss (>90 dB) and being at 'high risk in balance' although it is unclear if this high risk is solely related to the level of the child's deafness or if other factors were in play (e.g. parent/teacher evaluation of play etc.). d/Deaf children with additional visual, physical, neurological, and cognitive impairments were excluded from the study again limiting generalisability. Once again, the children's language use, lateralisation of deafness, and use of hearing equipment were not specified. Additionally, the authors specify ‘total communication’ was used to instruct the d/Deaf children but this is a very broad language system encapsulating signs, lip-reading, and spoken and written language which needs to be tailored to each individual child by experienced professionals who know a young person well in order to ensure accurate communication. In summary, there is a suggestion of difference in vestibular processing and balance among d/Deaf children, but the impact of this, if any, on activities of daily living and mental wellbeing remains unknown. Participants in the studies present with varying degrees of deafness which are not accounted for in analyses and are selectively screened for inclusion (e.g. Walicka-Cupryś et al.'s 2014 study). In addition, language use, and use of hearing equipment has largely been neglected as a factor in these analyses despite evidence that cochlear implants and sign language communication can contribute to difference in neural responses and the response of the central nervous system in processing sensory stimuli (Suarez et al., 2007).

Motor.

A thread of research suggests d/Deaf children perform, on average, significantly worse than hearing children on tests of motor development (Dummer et al., 1996; Gheysen et al., 2008) and there is some suggestion that a lack of early auditory input contributes to motor delays in d/Deaf children (Savelsbergh et al., 1991). More specifically, d/Deaf children have been reported to show lower scores on measures of general dynamic coordination, visual-motor skills such as ball-catching (e.g. slower reaction times, speed of movement), complex movement production, and movement sequencing disturbances (Conway et al., 2001; Hartman et al., 2011; Savelsbergh et al., 1991; Schlumberger et al., 2004; Siegel et al., 1991; Wiegersma & Van der Velde, 1983). Motor skills in d/Deaf adults have been less studied however, some research has suggested visual-motor and complete motor learning skills in d/Deaf adults are not significantly different from hearing controls (Hauser et al., 2007; Lévesque et al., 2014). Again, while these findings are interesting and suggest differences in motor-related experiences for d/Deaf children, the impact, if any, on activities of daily living and mental wellbeing is unclear.

Tactile Processing.

A 1968 study by Chakravarty found greater sensitivity for detecting the location of tactile stimulation in d/Deaf children compared to age and gender matched hearing controls, suggesting an advantage in tactile processing for d/Deaf participants. However, level of hearing loss, equipment and language use, and communication methods used when carrying out the study were not specified. Additionally, the introduction of the paper hints at a 'fascination' with d/Deaf and deafblind individuals such as Helen Keller, potentially suggesting bias on the part of the researcher which is not reflected upon or explored. Another study by Heming & Brown (2005) found temporal thresholds for tactile stimulation (i.e. the time taken to detect touch) were significantly higher in d/Deaf participants than matched hearing controls suggesting a disadvantage in tactile processing for d/Deaf participants. Sample sizes in these studies were small (n = 12 and n = 20, respectively) and differences were a matter of millimetres/seconds which, while statistically significant, have limited implications for tactile sensory processing in daily life. Later a larger study of 300 children found d/Deaf young people were more sensitive to vibrotactile stimulation than matched hearing controls and increasing palmar sensitivity with age in the d/Deaf group. Again these were clinically marginal differences and there were no differences in other areas of processing such as tactile object identification, or pattern or texture discrimination (Schiff & Dytell, 1972). The finding of greater sensitivity to vibrotactile stimulation is somewhat supported by a 2001 study which suggested d/Deaf participants were statistically better at detecting suprathreshold changes (changes above the conscious threshold) in tactical stimuli compared to hearing controls (Levanen & Hamford, 2001). In the most recent study in this review Papagno, Minniti, Mattavelli, Mantovan, & Cecchetto (2017) compared deafblind, d/Deaf, blind, and hearing/sighted matched controls in their performance on tactile, short-term memory tasks. Blind and d/Deaf participants outscored controls on measures of item complexity and tactile span, and number of correct responses suggesting better memory for tactile information. There was no significant difference in performance between blind and d/Deaf participants who do not share blind people's experience of a tactile language system and as both groups outperformed the hearing controls this finding cannot be explained by any practice effect related to experience with tactilely encoded information (Papagno et al., 2017). Only one paper comparing Deaf people with hearing sign language users as well as hearing non-signers was identified. This study found both Deaf people and hearing sign language users outperformed the hearing non-signers in haptic matching tasks (matching shapes to cut-outs as fast as possible) (van Dijk et al., 2013). This study neatly demonstrates the importance of considering language use in addition to deafness as in this case controlling for visual language use negated observed differences between Deaf and hearing subjects. In summary, the research covers a broad range of areas within tactile processing among d/Deaf people but is predominantly limited to comparison with blind and/or non-signing participants, largely neglecting the role of language. Additionally, while statistically significant differences in temporal thresholds and sensitivity to the localisation of stimulation have been identified between d/Deaf and hearing participants, these findings are derived from highly artificial, lab-based research with little-to-no applications or impact and limited clinical utility.

Olfactory Processing.

Studies exploring olfactory functioning among d/Deaf people have been methodologically flawed, generating conflicting results which are of limited real-world application. One study reported differences in brain activation in response to olfactory stimulation between d/Deaf, blind, and hearing participants (Ozgoren et al., 2011). In this study, additional areas of the brain located towards the auditory cortex were active in response to olfactory stimulation in d/Deaf participants but not among hearing and blind comparison groups (Ozgoren et al., 2011). A similar study in 2012 later found no significant difference in neurological response to olfactory stimulation between blind, d/Deaf, and hearing participants (Ozgoren et al., 2012). A third study, which required teenaged participants to verbally identify smells found d/Deaf participants had less success differentiating between smells and detected smells at a higher threshold compared to hearing or blind participants (i.e. smells were stronger when first detected by d/Deaf participants compared to other groups) (Guducu et al., 2016). This led the researchers to determine hyposmia in 58% of participants in the d/Deaf group compared to 10% in the hearing group and 36% in the blind group (Guducu et al., 2016). The results of this later study should be interpreted cautiously. Three lab workers affiliated with the study learnt ‘basic’ sign language specifically to undertake this piece of work and while it is reported a ‘teacher’ from their school accompanied d/Deaf participants to the lab, no further information regarding their signing skills or role in communicating instructions during the study are given. Furthermore, during the odour discrimination test d/Deaf participants were asked to choose between smells by pointing at words on a piece of paper which would be a slower than giving verbal responses. In addition, assessment of the d/Deaf participants’ language skills (reading or signed) is not reported. As such, is it unclear if the results obtained reflect genuine differences in odour detection and discrimination among the d/Deaf participants or reflect unclear instructions, differences in testing procedure, or a lack of smell related vocabulary (signed and/or written) arising from restricted/delayed access to language. In their publication the authors do urge some caution in the interpretation of their results but frame concerns in terms of ‘low collaboration’ from d/Deaf participants (Guducu et al., 2016).

Oral Sensitivity, Auditory Processing, and Mental Health.

No relevant papers relating to oral processing, auditory processing, or mental health were identified. No papers on oral processing were identified at all while any papers related to auditory processing were linked to medical interventions (e.g. cochlear implants), neurological structures of the auditory cortex, or physical structures of the ear all of which lie outside the scope of the current project. No papers exploring sensory processing and mental health were found and none of the papers reviewed referenced mental wellbeing in relation to the sensory processing experiences of d/Deaf people.

Sensory Processing and d/Deaf Children.

There are some indications that d/Deaf children may be more at risk of greater levels of sensory processing needs than their hearing peers. A paper by Crowe & Horak (1988) exploring sensory organisation in the motor domain among seven to 13 year old d/Deaf children found diminished organisation in three of the 29 participants. This categorisation was made based on the children displaying multiple motor deficits despite normal vestibular functioning. Given the limitations of this study such as a small sample size, differing aetiologies of deafness, unclear levels of hearing loss among the group as a whole (specified only as above 30dB all children in the group with no upper limit given), unclear language use by the children and in the running of the experiment (for instance, maybe these children did not understand what was being asked of them in the tasks), and a focus on a single area of sensory processing (motor) the conclusions that can be drawn from this study are very limited. In another study which aimed to evaluate global language development in 40 children with hearing loss (hearing aid and cochlear implant users, 20-40 months old, hearing loss 15-120dB) receiving an intensive auditory-verbal intervention (one to four years), 78% of the children exhibited difficulties with sensory processing as assessed by occupational therapy evaluations with nearly two-thirds identified as having moderate to severe sensory processing needs (Rhoades & Chisolm, 2001). Unfortunately, this data was collected as demographic data to help contextualise the impact of the auditory-verbal approach to communication and no further details regarding sensory processing are given. Further suggestions of increased sensory processing needs among d/Deaf children arise from a more recent study in which scores of the parent-rated Sensory Profile Caregiver questionnaire for

30 d/Deaf children (two-10 years old, congenital, severe-profound hearing loss) with cochlear implants were combined with behavioural observations by Occupational Therapists (Bharadwaj et al., 2009). Children suspected of, or diagnosed with ASD, developmental delays, cognitive delays, blindness, or deafness acquired from cytomegalovirus or meningitis were excluded. 70% of the children assessed were defined as 'at-risk' or as having 'different' behaviour in one or more sensory areas (auditory, visual, vestibular, tactile, and oral processing). 'Atypical' behaviour was most prevalent in the auditory and vestibular modalities (40% of the sample) followed by the oral and tactile (approximately 25% of the sample), and least prevalent in the visual processing domain (10% of the sample). Both sensory-seeking and sensory-avoiding behaviour was observed among the sample. There was no correlation between duration of hearing loss and 'atypical' behaviour in any sensory category. A significant, low negative correlation (r = - 0.3, p = < .001) was found between duration of implant use and observed atypical behaviour for the vestibular category, supporting parental reports of atypical behaviours linked to vestibular processing somewhat diminishing with increasing length of implant use (Bharadwaj et al., 2009). While this study has many strengths caution must still be used in generalising these results to the wider d/Deaf paediatric population. Families who chose to take part in this study self-selected and as such there is a high risk of sample bias. In addition, language use is once again not explored. The evidence for increased sensory processing needs among d/Deaf children is limited in both scope and quality. However, while conservative estimates for sensory processing needs in the non-clinical, hearing paediatric population are 5%, unusual sensory processing was noted in 10% to 78% of d/Deaf children in the above studies (Bharadwaj et al., 2009; Crowe & Horak, 1988; Rhoades & Chisolm, 2001) putting d/Deaf children closer to estimates of need in other clinical groups such as children with a diagnosis of ASD or ADHD (e.g. Dunn, 2006; Tomchek & Dunn, 2007).

Summary

This review addressed the question: '*Are there differences in sensory processing between d/Deaf and hearing people*?'. There was no literature available for oral or auditory processing domains, however there was evidence of differences in visual, tactile, olfactory, and motor domains between d/Deaf and hearing populations across the lifespan and particularly in childhood. Whether these differences point to under-responsiveness or supranormal capabilities remains unclear. In addition, the impact of sensory processing on the daily lives and mental wellbeing of d/Deaf people remains unexplored.

The Scoping Review: Sensory Processing and Mental Wellbeing in d/Deaf Children

The absence of literature relating to sensory processing and mental wellbeing among d/Deaf people made a systematic review in this area impractical. As such a scoping review aiming to outline gaps in the literature and provide a 'first assessment' of research in this area was undertaken (Arksey & O'Malley, 2005). Here the term 'sensory' is used to refer to any sensory modality (sight, sound, smell, touch, taste, balance, or movement).

Search Strategy.

An electronic search of the Cochrane Database of Systematic Reviews, PubMed, and Scopus databases was carried out. Searches were carried out in November 2019. Boolean operators were used to combine the search terms, and search terms were truncated with the asterisk operator where appropriate (see table 5). Literature was searched from 2009, covering a ten-year period, using keyword, abstract, and title field searches. The search generated 2,074 papers. The first screening consisted of eliminating duplicates and reading titles and abstracts. 2,067 papers were removed with six full-text articles assessed for eligibility based on the full inclusion/exclusion criteria (see table 6). To provide the most comprehensive overview of the literature reference lists for articles were manually scanned for additional relevant papers. In total five papers were selected for inclusion in this review (see figure 3). Requests for 'grey literature' were also made to relevant organisations. 'Grey literature' refers to materials and research produced by organisations outside traditional academic settings and can include annual reports, research conducted outside of academic institutions, working papers, government documents such as white papers, and service evaluations. Requests were made to a national NHS service and charity supporting d/Deaf children, with neither able to contribute. Papers were screened for their comprehension in assessing both deafness and areas of sensory processing and their application to everyday living and mental health. Less attention was given to particular research methods or the assessment tools that were used. In May 2020, prior to submission of this thesis an additional literature search was undertaken. No new papers were generated.

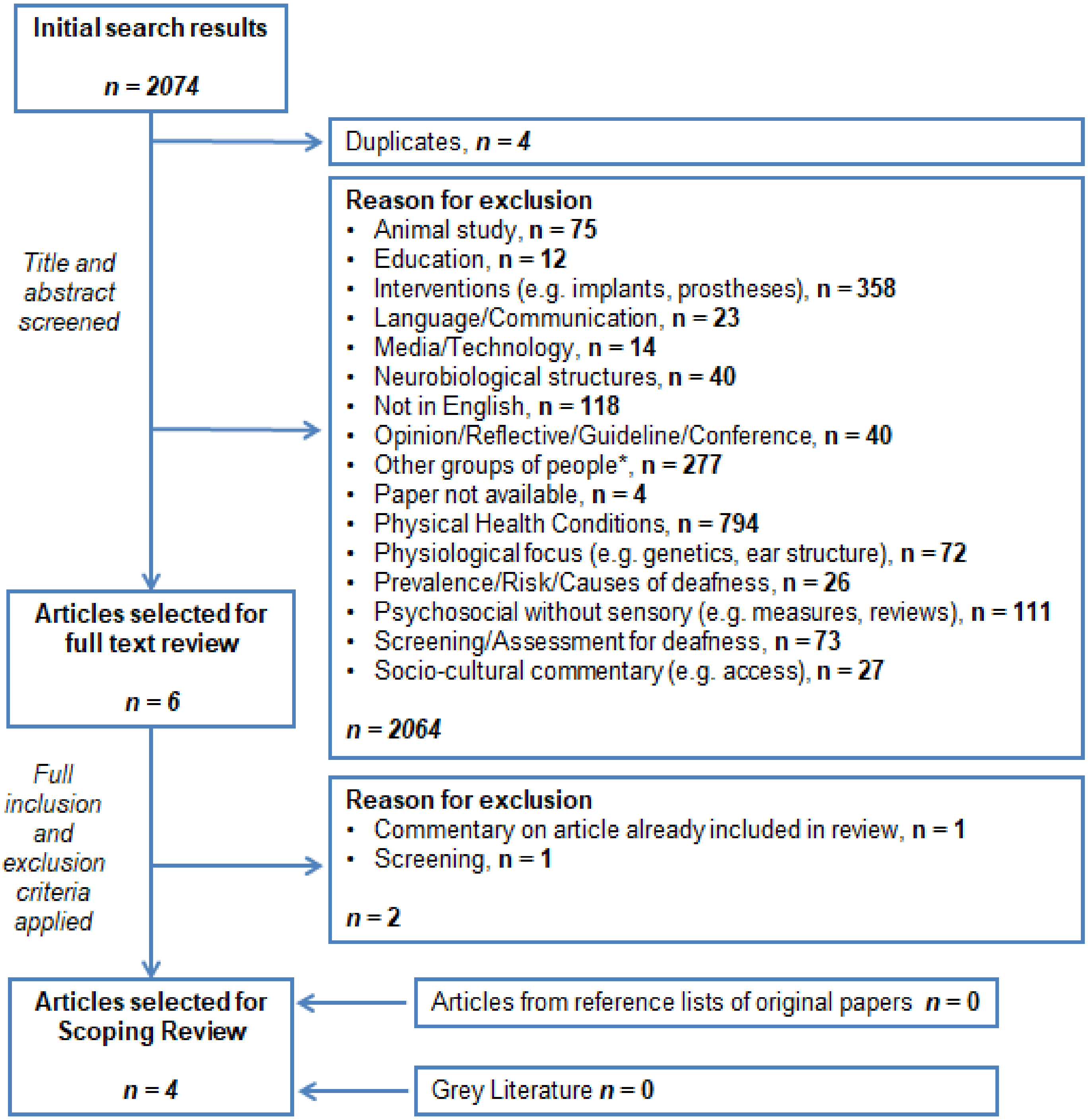
Table 5. Search Terms used for Scoping Review

Sensory Processing		Mental Health		d/Deaf
Sensory		Mental Health		
Sensory processing		Wellbeing		
Sensory processing dysfunction		Well-being		
Vestibular		Quality of Life		
Oral	*AND*	Depress*	*AND*	Deaf*
Auditory		Anxi*		
Motor		Psychosocial		
Tactile		Psycho-social		
		Mental Disorder		

Table 6. Scoping Review Inclusion and Exclusion Criteria

Inclusion	Exclusion
Pertains to d/Deaf people	Based on animal data
Sensory processing in any modality	Focused solely on physiological or neurological structures
Paper is available in English	Study focuses on other population
	Study focuses on physical or psychosocial interventions
	Literature solely concerned with linguistics or communication methods
	Solely concerning media/tech resources/developments
	Guidelines or conference notes
	Screening or measurement tool development or evaluations
	Socio-cultural commentary (reflections/reviews on access to education, mental health care or other public services)

Figure 3. Flow of Scoping Review



**blind, n = 2; deafblind, n = 22; hearing, n = 10; deafened in later life, n = 210; ID, n = 9; sudden hearing loss, n = 11; ASD, n = 13*

Table 7. Summary of Research Articles from Scoping Review.

Authors	Year	Research aim	Sample	Measures	Method	Findings
Systematic review						
Rajendran, Roy & Jeevanantham	2012a	Review of postural and motor skills, and health related quality of life in children with a hearing impairment			11.872 articles identified. 17 eligible with 5 using health related quality of life measures.	Children with hearing impairment exhibit suboptimal postural control, motor skills, and health-related quality of life across a range of ages and measurement tools.
Experimental Design						
Fellinger, Holzinger, Aigner, Beitel, & Fellinger	2015	To examine motor performance in children with hearing impairment and explore correlations with mental health	*n* = 93 Age - 6-16 HL >40dB IQ >70	Zurich Neuromotor Assessment Parent SDQ	Scores on ZNA, controlled for nonverbal IQ, were compared with scores on SDQ.	Children with hearing impairment scored significantly below norms in the ZNA (p = <.001). Motor difficulties were related difficulties in peer relationships and emotional distress.
Leigh, Ching, Crowe, Cupples, Marnane, & Seeto	2015	To evaluate the development of psychosocial and motor skills in children with hearing impairment at age 3.	*n* = 301 *M* age = 37.8mth HL 20 - >80dB	Child Development Inventory (CDI).	Evaluation of parent-rated CDI scores.	Psychosocial and motor developments within the typical range for hearing children. Large individual differences. Positive correlation between social and motor development. Positive correlation between language ability, and social and motor development. Children with hearing aids had higher gross motor scores than those with cochlear implants.

Authors	Year	Research aim	Sample	Measures	Method	Findings
Rajendran, Roy & Jeevanantham	2012b	To evaluate a vestibular-specific neuromuscular training programme's impact on children's motor and balance skills, and health-related quality of life	*n* = 23 Age 6 – 11 HL >90dB	PedsQL Generic Core Scale (quality of life). Test of gross motor development-2 (motor skills). Paediatric reach test, one leg standing balance test, and postural sway meter (postural control).	Random allocation to control or experimental group. Experimental group participated in vestibular-specific neuromuscular training for six weeks. Control group continued regular activities at school.	Intervention improved motor skills, postural control, and health-related quality of life scores. Vestibular-specific neuromuscular training may improve motor skills, balance, and physical and psychosocial health-related quality of life in children with hearing impairments.

Findings.

Research identified by this review is limited to the impact of motor and balance skills on quality of life and it is acknowledged that this is a step away from a consideration of how sensory processing experiences, in and of themselves, impact mental wellbeing. However this body of work does suggest a link between lowered balance and motor performance and decreased psychosocial wellbeing in d/Deaf children across a broad range of ages (Fellinger, Holzinger, Aigner, Beitel, & Fellinger, 2015; Rajendran, Roy, & Jeevanantham, 2012a, 2012b). Rajendran et al's (2012a) review explored motor and balance skills and quality of life as separate areas of interest with their 2012b study demonstrating that improvements in motor and balance skills were linked with improved scores on the psychosocial components of a health-related quality of life measure in a small sample (n = 23) of d/Deaf children (six to 11 years old). In this study participants were assigned to either a neuromuscular training programme (three one-to-one sessions for 45 minutes per week, for six weeks) or a non-active control. Baseline measures of motor skills and health-related quality of life were compared with post-intervention measures using appropriate statistical testing procedures; however, participants were not analysed as matched pairs. Pre-intervention group scores are not reported and therefore it is not possible to tell whether a significant difference between the two groups existed at baseline. The link between motor skills and mental wellbeing was also emphasised in Fellinger et al.'s (2015) study with d/Deaf students scoring significantly lower than the norms in an assessment of motor skill, and with poor motor performance related to difficulties with peer relationships and increased rates of emotional difficulties. In this study 93 d/Deaf children and young people (*Age* = 6 - 16,*M* = 11.3, *SD* = 2.9, *range* = 6.6-16) with hearing impairments of at least 40dB (*M* = 76.1dB, *SD* = 24.23, *range* = 40-120dB) were assessed for motor performance on the Zurich Neuromotor Assessment (ZNA), and mental health using the parent-rated Strengths and Difficulties Questionnaire (SDQ).On average 74% of the d/Deaf children scored in the bottom 15% of the ZNA with 57% scoring in the bottom 5%; however, these norms are based on hearing children and therefore must be used with caution when applying them to d/Deaf children. Children with high 'total difficulties' scores on the SDQ showed poorer performance in the motor subscale of the ZNA with peer relationship problems negatively correlated with motor performance, and dynamic balance subscales. Higher scores for emotional problems also correlated with lower performance on the dynamic balance subscale. In contrast, Leigh et al. (2015) found psychosocial and motor developments within typical ranges for hearing children in a group of 301 younger d/Deaf children (*M* = 37.8 months, *SD* = 1.7, *range* = 35-43, *hearing loss* = 20 -

>80dB) using the Child Development Inventory. However, Leigh et al. (2015) did note large individual differences between individual children and found those with hearing aids had higher gross motor scores than those with cochlear implants. This may be related to the aetiology of deafness in these children or degree of hearing loss, or reflect a greater number of children with hearing aids in the study (72.3% vs. 27.2%). Leigh et al. (2015) also found positive correlation between language ability and social development, language ability and motor development, and social and motor development suggesting a far more complex picture than hearing loss inevitably leading to any uniform impact on motor or psychosocial development. Further complicating the results of this study are the varying language uses by families participating in the study (Australian Sign Language (*n* = 2); mixed methods (*n* = 70); aural (*n* = 219)) and presence of additional disabilities (developmental delay (*n* = 39 (12.9%)); cerebral palsy (*n* = 23 (7.6%)); ASD; (*n* = 10 (3.3%))) which do not appear to have been factored into the analysis.

Overall Summary

There is evidence from other paediatric populations that sensory processing needs can negatively impact mental wellbeing, and that sensory processing needs can have a lifelong impact. There is also evidence that some groups of children are more likely to experience difficulties in processing sensory information than others and effective interventions are available to mitigate any negative impact of processing sensory needs. Currently the extent of any sensory processing needs among d/Deaf children, the sensory processing profiles of d/Deaf children, and the impact of any sensory processing needs on mental wellbeing among d/Deaf children is unknown. Almost paradoxically d/Deaf children seem to have been omitted from research in this area despite:

- Definitional differences in processing auditory stimuli
- Consistent indications of processing differences across multiple sensory domains compared with hearing controls
- Some suggestion of higher rates of sensory processing difficulties among d/Deaf children
- Increased levels of risk for developing mental health difficulties among d/Deaf children

Rationale and Research Aims

Research suggests that 5-10% of typically developing hearing children may have sensory processing needs. In some clinical populations estimates different sensory processing needs are significantly higher (e.g. for children with diagnoses of ADHD or ASD). The systematic and scoping reviews outline differences in sensory processing between d/Deaf and hearing populations in multiple sensory domains across the lifespan, but particularly in childhood. However, estimates of sensory processing needs among d/Deaf children remain unknown and the influence of any of these on their daily lives and mental wellbeing is unclear. Children with sensory processing dysfunction can show decreased social skills, lower self-confidence, self-esteem, and daily life skills, and diminished fine, gross, and sensorimotor skill development. For these children school and home environments can contain stimuli that cause significant levels of distress, fear, anxiety, or discomfort which can significantly disrupt their daily routines, academic performance, relationships, and psychological wellbeing. It is likely that any established links between sensory processing and mental health in hearing paediatric populations do not fully reflect the experiences of d/Deaf children who are known to be at increased risk of common mental health difficulties such as anxiety and depression in general and have increased rates of comorbid diagnoses, and unique experiences related to auditory processing and language. It is therefore possible that the impact of any sensory processing needs may lead to more significant difficulties for d/Deaf children, who are already members of a socially disadvantaged and marginalised group and also face increased barriers in accessing mental health support.

The current study aims to:

- Compare sensory processing profiles of d/Deaf children with typically developing children and children with a diagnosis of ASD or ADHD
- Explore the impact of degree of hearing loss and BSL and equipment use on sensory processing among d/Deaf children
- Explore the impact of sensory processing profiles on psychological distress among d/Deaf children aged 5 to 10 years old.

CHAPTER 3 - METHOD

"Thinking and planning is one side of life; doing is another" (Stewart, 1974)

The Original Plan

The original plan was to compare sensory processing and mental wellbeing between d/Deaf and hearing populations across the lifespan. However, sensory processing measures were not available in BSL and therefore a new measure would need to be developed, or an existing one translated. Creating a new measure was highly impractical and therefore a translation was considered. Ideally the processes by which other mental health measures have been translated from written English into BSL would then have been followed. This would have included gaining permission for the translation from, and collaborating with, the original authors of the measure, independent translations of measures by multiple registered Deaf interpreters and/or translators, validation meetings, numerous forward and back translations, field-testing, piloting, follow-up interviews to check understanding of items and gather feedback, reliability and validity testing, and the development of appropriate norms (e.g. as in Rogers, Dodds, Campbell, & Young, 2018). However, this went far beyond what was a possibility under the remit of the current project. In an attempt to continue with the original lifespan project Mrs F, a member of the Deaf community known professionally and personally to the lead author, was recruited to translate the Adolescent/Adult Sensory Profile (AASP) into BSL. This would have allowed for the inclusion of teenage and adult participants without the need for interpreters. Mrs F is a culturally Deaf woman with extensive experience working with d/Deaf individuals in a mental health setting. Her role specifically relates to the translation of medical, psychological, and legal materials, and she holds multiple qualifications in translating across written English and BSL. Mrs S is a qualified BSL interpreter known to both Mrs F and the lead author who also agreed to lend support to the project. Mrs S is a skilled interpreter with extensive experience in a range of settings, including academic and mental health domains. Mrs F agreed to offer consultation to the project overall, and both she and Mrs S agreed to aid with the translation of the AASP. Mrs F agreed to film herself signing the AASP questions so these could be uploaded to a survey hosting site, allowing participants to choose to complete the questionnaire in written English or BSL. Signed versions of the Strengths and Difficulties Questionnaires were obtained from the University of Manchester, with permission to use these as measures of psychological distress for adolescent and adult participants. Unfortunately, after several meetings Mrs F was unable to continue to support the project due to ill health. Without Mrs

F's assistance it was no longer possible to translate the AASP, as Mrs S was not able to offer the required hours needed to complete this work alone. The project team did not have the necessary skills to translate the questionnaire and the cost to hire a professional interpreter is, at minimum, £260 per day (National Union of British Sign Language Interpreters, 2020). Given the specialist nature of the work it is likely this would have attracted a higher fee (National Union of British Sign Language Interpreters, 2020). The budget for this project was £200 in total. Realistically Mrs F and Mrs S's generous offer to translate the AASP into BSL represented the minimum standards of acceptability. Without their assistance it was no longer feasible to translate the AASP without far more time and resources. The paediatric population was therefore focused upon because 90% of d/Deaf children are born to hearing parents who would be able to access the written English versions of the questionnaires (Mitchell & Karchmer, 2004). Furthermore, evidence from literature pertaining to visual abilities in d/Deaf children suggests greater levels of difference in d/Deaf children under the age of 10 years (Alencar et al., 2019) and larger effect sizes are easier to detect with smaller samples. Additionally, as estimates of sensory dysfunction in the adult, hearing, non-clinical population has been cited as similar to that seen among children (Engel-Yeger & Dunn, 2011) understanding sensory processing needs among d/Deaf children may tentatively be used to estimate possible needs among d/Deaf adults.

The Current Study

Research Questions

The current study aims to explore possible links between sensory processing profiles and psychological distress in d/Deaf paediatric populations. It is hypothesised that d/Deaf children with higher levels of sensory processing needs will present with more psychosocial and emotional difficulties. The current study also aims to explore the sensory processing profiles of d/Deaf children compared with typically developing children and those with diagnoses of ASD or ADHD. It is hypothesised that there will be a difference between sensory processing profiles of d/Deaf and typically developing children, and d/Deaf children and those with developmental disorders.

Research Design

This study is a quantitative, within group design which uses descriptive, and parametric and non- parametric inferential statistics.

Ethics

Ethical approval for this project was granted by the University of Hertfordshire's Health, Science, Engineering and Technology Ethics Committee with Delegated Authority. The protocol number is LMS/PGT/UH/03814 (see Appendix 3). This project did not require NHS ethics as recruitment was conducted via the UK school system and third-sector organisations. To comply with the Data Protection Act 2018 (DPA 2018) and General Data Protection Regulation (GDPR), data was anonymised to protect patients' identities and ensure confidentiality. Participants were informed that they could withdraw their data up to the date upon which analysis was due to commence (see Appendix 4). To facilitate this while maintaining anonymity participants created unique identifier codes as part of the survey. The purpose of the data collection was outlined, along with any potential uses for it. Qualtrics, a secure, online survey hosting site, approved by the University's ethics committee was used to collect data. Raw data was stored securely on an encrypted hard drive only accessible by the primary researcher.

Recruitment

Recruitment was undertaken through the UK school system, a national third-sector organisation supporting d/Deaf children, social media, and word of mouth. Specialist d/Deaf schools and mainstream schools with a hearing unit were contacted and provided with recruitment information to share with their pupils' parents. For these schools, recruitment posters for the parents of hearing children were also provided to recruit for a control group (see Appendix 5). Schools were identified via Google searches and from discussions with members of the Deaf community. Posts on social media, including that of the national third-sector organisation, and more general parenting forums were also undertaken (see Appendix 6 for a full list of recruitment avenues).

…and then Covid-19

In addition to the challenges this project faced during development, the global Covid-19 pandemic unfolded during the recruitment, analysis, and write-up stages. As a response to this emergency the UK Government took the advice of the World Health Organisation and closed all the schools in the country. Together my supervisors and I considered the practical and ethical implications of continuing to recruit in the face of significant levels of threat, increasing national and global anxiety, and dramatic changes in routine and the fabric of daily life. Ultimately, we felt we had no choice but to suspend our research activities. Fortunately, we had gathered completed data from the parents of d/Deaf children over the course of the project, although not as many as we would have liked, and were able to produce a sample which was in keeping with the size of samples in previous studies (e.g. children with diagnoses of ASD or ADHD). Unfortunately, recruitment of hearing controls had fallen behind that of the d/Deaf sample. The idea of pooling data from the parents of hearing children from this study with data collected in a previous study by the external supervisor was suggested. Were this permitted it would have been possible to develop a small number of matched pairs to use in the analysis however this could not be approved by the ethics committee. Ultimately this meant the original plan for a matched pairs analysis could not be carried out.

Participants

Participants in the study were parents of d/Deaf children aged between five and 10 years old, who completed a parent-rated measure of sensory processing and parent-rated measure of psychological distress, and the children on whom the data was based.

Inclusion/Exclusion Criteria

Data was excluded from the analysis if a child had a diagnosis such as ASD or ADHD which are linked to sensory processing needs, or a diagnosis of SPD. There were no other exclusion criteria.

Instruments

The parent/caregiver-rated Strengths and Difficulties Questionnaire (SDQ) (Goodman, 1997) was used as a measure of psychological distress. The Sensory Profile Caregiver Questionnaire (SPCQ) was also employed (Dunn, 2006). Demographic information related to a child's age, sex, language environment, and physical and psychological health were also collected. As it is widely accepted that approximately 90% of Deaf children are born to hearing parents (Mitchell & Karchmer, 2004), and given the limitations of the doctoral thesis, both in terms of finances, scope and timeframe, these measures were not translated to BSL or other spoken languages. As such d/Deaf children with parents or caregivers who find it difficult to access written English would have found it difficult to participate.

Strengths and Difficulties Questionnaire.

The SDQ is a short assessment instrument that addresses positive and negative behavioural attributes of children and adolescents and generates scores for clinically relevant aspects. The SDQ contains 25 questions aiming to identify emotional, behavioural, and social difficulties a child or young person may be experiencing and is often used clinically as an initial screening measure and to suggest areas for further investigation. Raw data from the SDQ can be used to generate a total score and scores for four subscales which identify distress expressed emotionally, through conduct, hyperactivity, or through interaction with peers. A fifth scale explores pro-social behaviour among respondents. The four 'problem' scales can be combined to give an overall score, and used to generate an 'externalising' behaviour scale (summing the conduct and hyperactivity scales) and an 'internalising' scale (summing the emotional and peer relationship scales). Using these two amalgamated scales may be preferable to using the four 'problem' scales in community samples, whereas using the four scales may add more value in high-risk samples (Goodman & Goodman, 2009). The SDQ is used in research and clinical settings worldwide, across multiple languages including BSL (Roberts et al., 2015) and comes with a considerable body of published work demonstrating its reliability and validity (e.g. Goodman & Goodman, 2011; Goodman, 1997; Kersten et al., 2016; Van Roy, Veenstra, & Clench-Aas, 2008) (see Appendix 7 for an extract of the measure). However this measure is not without criticism and concerns have been raised about the factor structure for condition-specific populations in clinical settings, the invariance between parent and teacher ratings, the predictive validity of the tool for specific disorders, and validity of the tool as a longitudinal outcome measure in research trials (see Hall et al, 2019 for a review).

The Sensory Profile Caregiver Questionnaire.

The Sensory Profile Caregiver Questionnaire (SPCQ) is a reliable, valid, parent-rated clinical tool used to assess sensory processing in young children (Dunn, 2006; Ohl et al, 2014). The SPCQ is a widely used as a diagnosis tool, outcome measure and research tool around the world (Benjamin et al., 2014; Dunn, 2006; Ohl et al., 2012). However, there are there are concerns regarding the use of both this and other measures of sensory processing with calls for further validation of all measures and concerns about the reliance on parent-rated measure in this area (Burns, Dixon,, Novack, & Granpeesheh, 2017). The SPCQ can provide information about a child's response to sensory stimuli and can be used to identify which sensory systems are likely to be creating barriers in a child's daily life (Dunn, 2006). It also offers comparative norms for neurotypical and atypical populations (Dunn, 2006). The SPCQ is comprised of 125 questions covering three main areas: Sensory Processing; Modulation; and Behavioural and Emotional Responses. The six Sensory Processing items explore areas of sensory processing which are part of everyday life. The five Modulation items reflect various combinations of sensory input which are part of daily life. The three Behavioural and Emotional Responses items cover emotional and behavioural responses to stimuli which might indicate a child's sensory processing abilities (Pearson Education, 2008) (see table 8). Respondents are asked to record the frequency at which their child displays each described behaviour/response on a 5-point Likert scale. The SPCQ was developed based on the performance of 1,037 children without disabilities (Dunn, 1999). Norms are also available for children with diagnoses of ASD or ADHD (Kientz & Dunn, 1997; Dunn & Bennett, 2002). The SPCQ can also analysed by totally raw scores in differing ways to compute Factor and Quadrant scores (Dunn, 2006; Dunn & Brown, 1997). The nine Factor scores can be used to gain an understanding of a child's thresholds and responsiveness to sensory events (see table 9) (Dunn, 2006; Dunn & Brown, 1997). The four Quadrant scores can be used to quantify the degree to which a child may miss, obtain, detect, or be bothered by sensory input (see table 10) (Dunn, 2006). In 2006 the *Sensory Profile Supplement User's Manual* was published to update the SPCQ assessment, ensuring that it reflects current understandings of sensory processing (Dunn, 2006). The SPCQ has been shown to have acceptable psychometric properties, with moderate-to-good test-retest reliability and moderate-to-high internal consistency (Dunn, 2006; Ohl et al., 2012). The new quadrant level of analysis was found to have better test-retest reliability and internal consistency than the original Factor method of analysis and has therefore been recommended for analysing a child's sensory processing patterns (Ohl et al., 2012). However, as neither analysis has ever been undertaken with a sample of d/Deaf children both will be undertaken in the current study as they offer different insights into sensory processing. The SPCQ has also been proposed as a possible intervention outcome measure (Ohl et al., 2012) (see Appendix 8 for an extract from the measure and Appendix 9 for the Technical Report).

Procedure

After giving informed consent parents/caregivers were asked to provide demographic information about their child including age, level of hearing impairment, language use, equipment use, comorbid diagnosis and medical history. They were then asked to complete the SDQ and SPCQ. Questionnaires were completed online using Qualtrics, a secure survey hosting site, approved for use by the ethics committee overseeing this project.

Table 8. SPCQ Items Descriptions

Sensory Processing	Modulation	Behavioural and Emotional Responses
Auditory Processing - responses to things that are heard.	**Sensory Processing Related to Endurance/Tone** - ability to sustain physical performance.	**Emotional/Social Responses** - psychosocial coping strategies.
Visual Processing - responses to things which are seen.	**Modulation Related to Body Position and Movement** - ability to move effectively	**Behavioural Outcomes of Sensory Processing** - ability to meet performance demands.
Vestibular Processing - responses to movement.	**Modulation of Movement Affecting Activity Level** - levels of activeness.	**Thresholds for Response** - ability to translate sensory information into behaviour matching the nature/intensity of sensory input.
Touch Processing - responses to stimuli that touch the skin.	**Modulation of Sensory Input Affecting Emotional Responses** – ability to use body senses to generate emotional responses.	
Multisensory Processing - responses to activities that contain a combined sensory experience.	**Modulation of Visual Input Affecting Emotional Responses and Activity Level** - ability to use visual cues to establish contact with others.	
Oral Sensory Processing - responses to touch and taste stimuli to the mouth.		

Table 9. SPCQ Factor Descriptions

Factor	Description
Factor 1: Sensory Seeking	Actively seeks sensory stimuli
Factor 2: Emotional Reactivity	Strong emotional reactions to stimuli
Factor 3: Low Endurance/Tone	Weak muscle tone/physical endurance
Factor 4: Oral Sensitivity	Sensitivity to oral sensory stimuli
Factor 5: Inattention/Distractibility	Appears to have difficulty concentrating and/or attending
Factor 6: Poor Registration	Difficulties detect sensory information
Factor 7: Sensory Sensitivity	Responds readily to lower levels of sensory stimuli
Factor 8: Sedentary	Preference for sedentary activities
Factor 9: Fine Motor/Perceptual	Fine motor skills (e.g. illegible writing, messy colouring)

Table 10. SPCQ Quadrant Descriptions

Quadrant	Description
Quadrant 1: Low Registration	Needs additional input to respond to sensory stimuli
Quadrant 2: Sensation Seeking	Actively seeks sensory stimuli
Quadrant 3: Sensory Sensitivity	Responds readily to low levels of sensory stimuli
Quadrant 4: Sensation Avoidant	Actively avoids sensory stimuli

Analytical Strategy

During analysis, a copy of the data was downloaded from Qualtrics and stored securely on an encrypted hard drive which was only accessible by the primary researcher. Data was analysed using quantitative methods. In the first instance a test of normality was applied. The outcome of this determined if relevant parametric or non-parametric tests were conducted. Specific analyses aimed to:

1. Compare the sensory profiles d/Deaf of children with norms for typically developing children and children with a diagnosis of ASD or ADHD.
2. Consider the impact of degree of deafness, equipment and BSL use on sensory processing
3. Consider the impact of sensory processing needs on psychological distress in d/Deaf children.

IBM's SPSS Statistics package, a commonly used statistical tool, could not be accessed when analysing the current data. Compatibility issues prevented the software from being downloaded from UH on the lead researcher's personal devices and the UH campus was closed due to the Covid-19 pandemic. As such data was analysed using
PSPP, a software application designed for the analysis of sampled data (GNU Operating System, 2019). PSPP is an example of free and open-source software and is intended as a free alternative for SPSS. PSPP offers comprehensive analytical capabilities including descriptive statistics, T-tests, ANOVA, linear and logistic regression, factor, cluster, and principal components analysis, and non-parametric testing. It can also produce a range of statistical graphs including histograms and scree plots (GNU Operating System, 2019). As such, PSPP offered most of the analytical functions required in the current project. Anything that was not available (e.g. some graphical outputs including boxplots and Q-Q plots) were generated using Microsoft Excel.

CHAPTER 4 - RESULTS

*"The goal is to turn data into information, and information into insight" (*Fiorina, *1999)*

Three regression analyses exploring the impact of sensory processing on psychological distress rated by parents in a sample of d/Deaf children (*N = 21)* were computed. Comparisons of sensory processing in the d/Deaf sample compared with norms for typically developing children and those with diagnoses of ASD or ADHD were undertaken. The impact of degree of hearing loss, and equipment and BSL use on sensory processing was also explored.

Demographic Information

Data from 29 participants was collected between August 2019 and March 2020. Three data sets were incomplete. Five were excluded due to additional diagnoses linked to sensory processing needs (ADHD (*n* = 1), ASD (*n* = 1), SPD (*n* = 1), ADHD and SPD (*n* = 2)). There were no other exclusion criteria. Data from 21 participants was accepted for analysis. The majority of the respondents were mothers (*n* = 20). Children ranged from 5.4 -10.9 years (*Mean* = 7.9, *SD* = 1.74; *Median* = 7.5) with roughly equal numbers of males and females (*n* = 12 and *n* = 9) (see table 11). There were roughly equal numbers of cochlear implant and hearing aid users (*n* = 10 and *n* = 11) (see table 12). The majority of children were diagnosed with moderate to profound hearing loss (*n* = 20), with most in the profound range (*n* = 11) (see table 12). All were from different families. For 10 children the cause of hearing loss was unknown. For seven the cause was genetic in origin (see table 12). In five families two parents signed. Two additional families listed only the mother as a signer. In one case a grandparent who did not live in the family home was the signer. In five families the highest level of qualification was BSL Level 1[4] or lower, in one family the highest was BSL Level 2[4], and in the remaining two it was BSL Level 3[4]. The primary language used at home was spoken English (*n* = 20), with one family using another spoken language. Five families reported using BSL at home with three of these also reporting using Makaton[5], Total Communication[6], and Sign Supported English[7] (SSE). Two additional families reported use of SSE at home (see table 13).

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[4] *BSL Level 1 - basic e.g. alphabet and numbers, single signs for animals, food, drink, weather.*
BSL Level 2 - simple sentence construction and vocabulary for education, work, and leisure
BSL Level 3 - more complex sentence construction and vocabulary for politics and heath

[5] *Makaton - a language system using symbols, signs and speech to enable people to communicate*

[6] *Total Communication - using different forms of communication to match the needs and abilities of the child*

Table 11. Age and Sex Related Demographic Information

Age (years)	**Mean (*SD*)**	7.9 (*1.74*)
	Median	7.5
	Min	5.4
	Max	10.9
Sex	**Male**	12
	Female	9
Age deafness diagnosised (years)	**Mean (*SD*)**	1.3 (*1.7*)
	Min	0
	Max	4.8

Table 12. Hearing Loss Related Demographic Information

Degree of Hearing Loss	**Profound (91 dB HL+)**	11
	Severe(71-90 dB HL)	5
	Moderate(41-70 dB HL)	4
	Mild(26-40 dB HL)	1
Cause of Hearing Loss	**Microtia Atresia**	1
	Enlarged Vestibular Aqueducts	1
	Cytomegalovirus	1
	Genetic - Not Specified	5
	Genetic - 18q Deletion	1
	Genetic - Connexin 26 gene	2
	Unknown	10
Hearing Equipment	**Cochlear Implant**	10
	Mean (*SD*) age at Cochlear Implant Implantation (years)	4.98 (*3.2*)
	Hearing Aids	11

Table 13. Use and Proficiency of Signed Language[8,7]in the Home

Sign language or language systems used at home	**Signers with level of skill per family**			
	Mother	**Father**	**Siblings**	**Grandparent**
BSL, SSE, Total Communication	BSL3	BSL3		
BSL	BSL3	BSL2	SSE	
BSL	BSL2			
SSE	BSL1			
BSL, SSE, Total Communication	BSL1	BSL1	Family Sign	
SSE	BSL1	BSL1		
BSL, Makaton	Basic	Basic	Basic	
None				BSL 1

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[7] *SSE - Manually-coded English. Signs from BSL fit to the grammar and structure of spoken English.*
[8] *Makaton, Total Communication, and SSE are language systems not languages. They have been included in this table as parents identified them as methods of communication in the home. They should not be considered full and complete languages in their own right or as alternatives to BSL.*

Comparing the Sensory Processing Profiles of d/Deaf Children

Categorisations of Sensory Profiles.

Responses for each area of sensory processing can be categorised as ‘typical’ or ‘atypical’. Scores in the ‘atypical’ ranges represent scores above or below one to two standard deviations of norms based on typically developing, hearing children (Dunn, 1999). When children are categorised as having ‘atypical’ responses it indicates difficulties with an area of processing, suggesting it could be confusing or upsetting, or not meaningful to a child and may interfere with their abilities to complete tasks, tolerate certain environments, or engage with others.

Item Scores.

In the d/Deaf sample (*N* = 21) 29 - 76% of children fell outside of the ‘typical’ response range in each area when norms based on typically developing, hearing children were used (see table 14 and Appendix 10 for a more detailed view). Within the d/Deaf sample 76% of children fell outside of the ‘typical’ range on the Auditory Processing Item - a child’s responses to things that are heard. This was not surprising given 16 children were severe to profoundly deaf. However, a high percentage of children also fell outside of the ‘typical’ response range for input from other sensory modalities. Means and standard deviations for the d/Deaf sample were used to redefine the cut-offs with scores one to two standard deviations above or below the mean still categorised as outside of the ‘typical’ range. This analysis obviously lacks power, validity, and reliability and is not proposed as a norm for d/Deaf children’s sensory profiles. However, it does demonstrate that a ‘typical’ sensory profile of a d/Deaf child may be different to that of a hearing child as, with this new cut-off, only 33% of the sample fell outside of the ‘typical’ range for Auditory Processing (see tables 14 and 15).

Factor Scores.

In the d/Deaf sample (*N* = 21) 19-71% of children fell outside of the ‘typical’ range in each Factor when norms based on typically developing, hearing children were used (see table 14).

Quadrant Scores.

In the d/Deaf sample (*N* = 21) 52 - 67% of children fell outside of the ‘typical’ range in each Quadrant when norms based on typically developing, hearing children were used (see table 14).

Table 14. Percentage of d/Deaf Children with 'Typical' and 'Atypical' Responses for each Item, Factor and Quadrant

	'Atypical'	'Typical'
Auditory Processing	76%	24%
Visual Processing	38%	62%
Vestibular Processing	43%	57%
Touch Processing	38%	62%
Multisensory Processing	48%	52%
Oral Sensory Processing	43%	57%
Sensory Processing Related to Endurance or Tone	38%	62%
Modulation Related to Body Position and Movement	48%	52%
Modulation of Movement Affecting Activity Level	48%	52%
Modulation of Sensory Input Affecting Emotional Responses	48%	52%
Modulation of Visual Input Affecting Emotional Responses and Activity Level	57%	43%
Emotional/Social Response	43%	57%
Behavioural Outcomes of Sensory Processing	48%	52%
Items Indicating Thresholds for Response	29%	71%
Factor 1: Sensory Seeking	57%	43%
Factor 2: Emotional Reactivity	43%	57%
Factor 3: Low Endurance/Tone	62%	38%
Factor 4: Oral Sensitivity	33%	67%
Factor 5: Inattention/Distractibility	71%	29%
Factor 6: Poor Registration	33%	67%
Factor 7: Sensory Sensitivity	29%	71%
Factor 8: Sedentary	48%	52%
Factor 9: Fine Motor/Perceptual	19%	81%
Quadrant 1: Low Registration	67%	33%
Quadrant 2: Sensation Seeking	48%	52%
Quadrant 3: Sensory Sensitivity	43%	57%
Quadrant 4: Sensation Avoidant	41%	48%

Table 15. Percentage of d/Deaf Children outside of Typical Range in each area (descending on typically developing norms)

	Percentage Outside 'Typical' Range	
	Based on Typically Developing	Based on d/Deaf Sample
Auditory Processing	76%	33%
Visual Processing	38%	100%
Vestibular Processing	43%	19%
Touch Processing	38%	29%
Multisensory Processing	48%	24%
Oral Sensory Processing	43%	24%
Sensory Processing Related to Endurance or Tone	38%	14%
Modulation Related to Body Position and Movement	48%	33%
Modulation of Movement Affecting Activity Level	48%	27%
Modulation of Sensory Input Affecting Emotional Responses	48%	38%
Modulation of Visual Input Affecting Emotional Responses and Activity Level	57%	48%
Emotional/Social Response	43%	90%
Behavioural Outcomes of Sensory Processing	48%	24%
Items Indicating Thresholds for Response	29%	5%

Statistical Comparisons with Typically Developing and Atypical Populations.

Mean sensory profile scores for typically developing children (Dunn, 1999; Dunn & Brown, 1997), and those with a diagnosis of ASD (Kientz & Dunn, 1997) and ADHD (Dunn & Bennett, 2002) were collated and compared with mean scores for the d/Deaf sample. These norms were available for the Item and Factor analysis of the SPCQ but not the Quadrant analysis (Dunn, 2006). For typically developing children age-dependent norms are available. Given the limitations in sample size it was not possible to compare age-dependent subsets of the d/Deaf sample with the relevant norms. Instead, in line with Van der Linde's (2003) analysis of children diagnosed with specific language impairment the mean age of the sample (7.9, *SD* = 1.74) was used to determine which norm to use. Norms for children with a diagnosed of ASD and ADHD were not age dependent.

Item Scores.

Mean scores for d/Deaf children were lower than those of typically developing children for each Item. Standard deviations for all sensory processing Items were higher in the d/Deaf sample than for the typical developing norms. However, they were in line with standard deviations for children with diagnoses of ASD or ADHD. This indicates there may be larger variations in sensory processing scores for children in the d/Deaf sample when compared with typical developing children. A series of One-Sample t-tests were used to explore if there were statistically significant differences between mean scores of the sample of d/Deaf and norms for children in the three comparison groups (see table 16 and Appendix 10).

Typically Developing Children.

There was a significant difference in the mean scores of the d/Deaf sample and the norm for typically developing children on all Items of the SPCQ ($p = <.001$ on twelve items, $p = <.01$ on two items, see table 16).

Children with a Diagnosis of ASD.

There was a significant difference in the mean scores of the d/Deaf sample and the norm for children with a diagnosis of ASD (see table 16) for:

- Visual Processing – responses to things which are seen
- Touch Processing – responses to stimuli that touch the skin
- Multisensory Processing – responses to activities containing combined sensory experience
- Oral Sensory Processing – responses to touch and taste stimuli to the mouth

- Sensory Processing Related to Endurance/Tone – ability to sustain physical performance
- Modulation Related to Body Position and Movement – ability to move effectively
- Modulation of Movement Affecting Activity Level – demonstration of activeness
- Modulation of Sensory Input Affecting Emotional Responses – ability to use body senses to generate emotional responses
- Modulation of Visual Input Affecting Emotional Responses and Activity Level – ability to use visual cues to establish contact with others
- Emotional/Social Responses – psychosocial coping strategies
- Behavioural Outcomes of Sensory Processing – ability to meet performance demands
- Thresholds for Response – ability to translate sensory information into behaviour matching the nature and/or intensity of the input.

Children with a Diagnosis of ADHD.

There was a significant difference in the mean scores of the d/Deaf sample and the norm for children with a diagnosis of ADHD (see table 16) for:

- Visual Processing – responses to things which are seen
- Vestibular Processing – responses to movement
- Touch Processing – responses to stimuli that touch the skin
- Multisensory Processing – responses to activities containing combined sensory experience
- Oral Sensory Processing – responses to touch and taste stimuli to the mouth
- Modulation Related to Body Position and Movement – ability to move effectively
- Modulation of Movement Affecting Activity Level – demonstration of activeness
- Modulation of Visual Input Affecting Emotional Responses and Activity Level – ability to use visual cues to establish contact with others
- Emotional/Social Responses – psychosocial coping strategies
- Behavioural Outcomes of Sensory Processing – ability to meet performance demands
- Thresholds for Response – ability to translate sensory information into behaviour matching the nature and/or intensity of the input.

For all significant results, the 95% Confidence Interval did not include zero (see Appendix 13).

Table 16. Mean Scores from Different Comparison Groups (Items)

	d/Deaf		Typical			Autism			ADHD		
	Mean	SD	Mean	SD	*p*	Mean	SD	*p*	Mean	SD	*p*
Auditory Processing	25.86	5.89	34.02	5.22	<0.001	25.00	5.10	0.513	23.80	5.40	0.125
Visual Processing	36.57	6.32	37.52	4.88	<0.001	30.60	6.00	<0.001	30.50	5.70	<0.001
Vestibular Processing	46.14	7.42	51.69	3.46	<0.001	42.80	4.70	0.052	42.70	7.20	0.046
Touch Processing	77.19	10.05	80.62	7.92	<0.001	60.10	10.60	<0.001	65.40	10.10	<0.001
Multisensory Processing	27.33	6.09	30.45	2.92	<0.001	20.70	4.30	<0.001	22.30	3.80	0.001
Oral Sensory Processing	49.14	10.01	52.49	6.93	<0.001	38.20	10.00	<0.001	44.40	9.80	0.042
Sensory Processing Related to Endurance/Tone	38.90	7.61	42.86	3.31	<0.001	34.40	8.70	0.013	36.90	8.00	0.241
Modulation Related to Body Position and Movement	42.67	6.04	45.61	3.97	<0.001	35.90	5.50	<0.001	36.60	6.70	<0.001
Modulation of Movement Affecting Activity Level	24.95	4.31	27.47	3.13	<0.001	21.40	3.20	0.001	21.80	4.00	0.003
Modulation of Sensory Input Affecting Emotional Responses	15.52	3.80	18.15	1.83	0.003	11.70	2.90	<0.001	14.30	2.70	0.156
Modulation of Visual Input Affecting Emotional Responses and Activity Level	16.00	2.85	17.18	2.16	<0.001	12.60	2.40	<0.001	12.60	2.70	<0.001
Emotional/Social Response	63.48	3.34	71.41	8.97	<0.001	50.90	8.40	0.001	53.00	9.60	0.005
Behavioural Outcomes of Sensory Processing	22.52	6.25	25.46	2.83	0.004	16.90	3.10	0.001	19.30	3.90	0.028
Items Indicating Thresholds for Response	12.48	2.54	13.52	1.41	<0.001	10.10	2.80	<0.001	10.00	2.30	<0.001

Table 17. Mean Scores from Different Comparison Groups (Factor)

	d/Deaf		Typical			Autism			ADHD		
	Mean	SD	Mean	SD	*p*	Mean	SD	*p*	Mean	SD	*p*
Factor 1: Sensory Seeking	74.10	7.30	65.81	13.03	0.009	56.10	10.40	0.003	51.90	12.50	<0.001
Factor 2: Emotional Reactivity	65.20	9.10	57.43	16.09	0.039	43.00	8.30	0.001	46.00	10.20	0.004
Factor 3: Low Endurance/Tone	42.30	3.50	38.90	7.61	0.054	34.40	8.70	0.013	36.90	8.00	0.241
Factor 4: Oral Sensitivity	39.20	5.40	36.48	8.43	0.154	30.50	7.00	0.004	33.50	8.30	0.121
Factor 5: Inattention/Distractibility	27.90	3.70	21.95	5.70	<0.001	19.90	4.30	0.114	18.00	4.60	0.005
Factor 6: Poor Registration	36.70	3.40	35.05	3.90	0.067	27.50	5.20	<0.001	30.90	4.50	<0.001
Factor 7: Sensory Sensitivity	18.40	2.10	16.90	3.88	0.093	15.00	4.50	0.036	16.60	3.20	0.723
Factor 8: Sedentary	15.00	2.60	13.81	4.32	0.221	12.90	4.30	0.346	13.70	3.50	0.909
Factor 9: Fine Motor/Perceptual	13.40	1.80	12.14	3.41	0.107	7.10	2.33	<0.001	9.60	2.50	0.003

Factor Scores.

Like children with a diagnosis of ASD or ADHD, mean scores for d/Deaf children were lower than those of typically developing children in each Factor. Standard deviations for all sensory processing Factors were higher in the d/Deaf sample than for the typical developing norms. However, they were broadly in line with standard deviations for children with diagnoses of ASD or ADHD. This indicates there may be larger variations in sensory processing scores for children in the d/Deaf sample when compared with typically developing children, but not when compared with children with diagnoses of ASD or ADHD. A series of One-Sample t-tests were used to explore differences between mean scores for the d/Deaf children and norms for the three comparison groups (see table 17 and Appendix 10).

Typically Developing Children.

There was a significant difference in the mean scores of the d/Deaf sample and the norm for typically developing children for Factor scores related to sensory seeking behaviour, emotional reactivity, and inattention/distractibility (see table 17).

Children with a Diagnosis of ASD.

There was a significant difference in the mean scores of the d/Deaf sample and the norm for children with a diagnosis of ASD for sensory seeking behaviour, emotional reactivity, low levels of physical endurance/muscle tone, sensitivity to oral sensory input, poor registration of sensory, sensitivity to sensory input, and diminished fine motor skills (see table 17).

Children with a Diagnosis of ADHD.

There was a significant difference in the mean scores for the d/Deaf sample and norms for children with a diagnosis of ADHD for sensory seeking behaviour, emotional reactivity, inattention/distractibility, lower registration of sensory input, and diminished fine motor skills (see table 17).

Summary of Comparisons.

Categorising d/Deaf Children's Sensory Profiles

- 29 - 76% of the d/Deaf sample fell outside of the 'typical' range based on norms for typically developing hearing children for each Item of sensory processing.
- 19-71% of the d/Deaf sample fell outside of the 'typical' range based on norms for typically developing hearing children for each Factor.

Comparison with Typically Developing Children

- Mean scores were lower than norms for all Items and Factors of the SPCQ.
- These differences were significant for all Items of the SPCQ.
- There were significant differences in some Factor scores (see table 18).

Comparison with Children with a diagnosis of ASD

- Mean scores were higher than norms on all Items and Factors of the SPCQ.
- There were significant differences in some Item and Factor scores (see table 18).

Comparison with Children with a diagnosis of ADHD

- Mean scores were higher than norms on all Items and Factors of the SPCQ.
- There were significant differences in some Item and Factor score (see table 18)

It is acknowledged these analyses were undertaken with a small sample size, although one that is similar in size to samples in previous sensory processing studies and as such caution must be taken when interpreting the results. However, these results tentatively support the hypothesis that neuro-atypical d/Deaf children may have differing sensory profiles compared to typically developing children and children with diagnoses of ADHD or ASD.

Table 18. SPCQ Items and Factors with Significant Mean Differences Between d/Deaf Sample and Norms by Comparison Group

Typical	ASD	ADHD
Items		
All Items	**Visual Processing** – responses to things which are seen	**Visual Processing** – responses to things which are seen
	Touch Processing – responses to stimuli that touch the skin	**Vestibular Processing** – responses to movement
	Multisensory Processing – responses to activities containing combined sensory experience	**Touch Processing** – responses to stimuli that touch the skin
	Oral Sensory Processing – responses to touch and taste stimuli to the mouth	**Multisensory Processing** – responses to activities containing combined sensory experience
	Sensory Processing Related to Endurance/Tone – ability to sustain physical performance	**Oral Sensory Processing** – responses to touch and taste stimuli to the mouth
	Modulation Related to Body Position and Movement – ability to move effectively	**Modulation Related to Body Position and Movement** – ability to move effectively
	Modulation of Movement Affecting Activity Level – demonstration of activeness	**Modulation of Movement Affecting Activity Level** – demonstration of activeness
	Modulation of Sensory Input Affecting Emotional Responses – ability to use body senses to generate emotional responses	**Modulation of Visual Input Affecting Emotional Responses and Activity Level** – ability to use visual cues to establish contact with others
	Modulation of Visual Input Affecting Emotional Responses and Activity Level – ability to use visual cues to establish contact with others	**Emotional/Social Responses** – psychosocial coping strategies
	Emotional/Social Responses – psychosocial coping strategies	**Behavioural Outcomes of Sensory Processing** – ability to meet performance demands
	Behavioural Outcomes of Sensory Processing – ability to meet performance demands	**Thresholds for Response** – ability to translate sensory information into behaviour matching the nature and/or intensity of the input.
	Thresholds for Response – ability to translate sensory information into behaviour matching the nature and/or intensity of the input.	
Factors		
Factor 1 - Sensory Seeking	**Factor 1** - Sensory Seeking	**Factor 1** - Sensory Seeking
Factor 2 - Emotional Reactivity	**Factor 2** - Emotional Reactivity	**Factor 2** - Emotional Reactivity
Factor 5 - Innattention/Distractablity	**Factor 3** - Low Endurance/Tone	**Factor 3** - Low Endurance/Tone
	Factor 4 - Oral Sensitivity	**Factor 5** - Innattention/Distractablity
	Factor 6 - Poor Registration	
	Factor 7 - Sensory Sensitivity	
	Factor 9 - Fine Motor/Perceptual	

The Impact of Degree of Hearing Loss, Equipment Use, and BSL Use

A series of one-way ANOVAs (and non-parametric equivalents where appropriate) were used to explore the impact of degree of hearing loss (mild, moderate, severe, profound), equipment use (cochlear implants, hearing aids) and BSL use on sensory processing scores.

No effect of degree of hearing loss or BSL use was found for Items, Factor, or Quadrant analysis of the SPCQ. No effect of equipment use was found on the Factor analysis.

A large significant effect of equipment use was found on the Items analysis for a child's ability to sustain physical performance (Sensory Processing Related to Endurance/Tone - χ^2 (1, N = 21) = 5.46, p = .02, φ = .5), with children with hearing aids showing decreased performance compared to those with implants (*Median* = 14.25 and 8.05, respectively) (see table 19).

A large, significant effect of equipment use was also found for low registration of sensory input (Quadrant 1 – Low Registration - χ^2 (1, N = 21) = 5.75, p = .02, φ = .5), with children with hearing aids showing lower registration compared to those with implants (*Median* = 45 and 37, respectively) (see table 20).

For both these analyses the Kruskal–Wallis One-Way Analysis of Variance, a rank-based, nonparametric test used to determine statistically significant differences between groups, was used as the Homogeneity of Variance and was statistically significant in both these cases.

Table 19. Effect of equipment on Endurance/Tone (Item Analysis)

	Chi-Square	df	Asymp. Sig
Sensory Processing Related to Endurance/Tone	5.46	1	0.017

Table 20. Effect of equipment use on Low Registration (Quadrant Analysis)

	Chi-Square	df	Asymp. Sig
Quadrant 1: Low Registration	5.75	1	0.016

The impact of duration of cochlear implant use on sensory processing was not analysed due to the limited number of children with implants (n = 10). The impact of aetiology of deafness on sensory processing was not analysed due to limitations of the information available for children in the sample (e.g. unknown aetiology, n = 10, and aetiology attributed to 'genetics' without further specification, n = 5, see table 12).

The Impact of Sensory Processing on Psychological Distress

Mental Wellbeing: SDQ Scores

The SDQ scores for the d/Deaf children in the sample were computed to gain an understanding of mental wellbeing within the sample (see table 21). On the Emotional, Conduct, Hyperactivity, Prosocial, and Total scales the majority of young people scores in the 'normal' range. However, in all but the Hyperactivity scale approximately one quarter to one third of the young people scored 'abnormal' range suggesting significant difficulties in these areas despite the sample being non-clinical. In the Peer Problems all the young people scored in the 'abnormal' range suggesting significant interpersonal difficulties with peers among the sample.

Table 21. SDQ Scores for d/Deaf children

	Emotional		Conduct		Hyperactivity		Peer Problems		Prosocial		Total	
Abnormal	6	29%	5	24%	2	10%	21	100%	5	24%	7	33%
Borderline	1	5%	4	19%	1	5%	0	0%	1	5%	0	0%
Normal	14	67%	12	57%	18	86%	0	0%	14	67%	14	67%

Sensory Processing and Mental Wellbeing: Three Regression Analyses

Regressions for all three methods of analysis available in the SPCQ were conducted to assess if one method was more predictive of psychological distress among d/Deaf children than the others. This was undertaken via three multiple linear regressions. The first regression assessed the goodness of fit for a model predicting mental wellbeing distress (measured by the SDQ) based on the SPCQ's Items. The second explored goodness of fit based on the Factor method of analysis. The third explored goodness of fit based on the Quadrant method of analysis.

Items Regression.

A multiple linear regression predicting levels of psychological distress based on sensory processing scores was conducted. The dependent variables were scores on the SDQ (Total, Emotional, Conduct, Hyperactivity, Peer Relationships, Pro-social Behaviour scales, and the Externalising (Conduct + Hyperactivity scale scores) and Internalising scales (Emotional + Peer scale scores). The independent variables were Items scores on the SPCQ assessing the processing of input from sensory systems (see table 8).

Descriptive Statistics.

The SDQ scales and Item variables were all normally distributed, producing non-significant results on the Kolmogorov-Smirnov test of normality (see tables 22 and 23). Given the small sample size there was a concern this test would not be sensitive enough to adequately detect abnormalities in the distribution so skew and kurtosis were also computed (see tables 24 and 245. In addition, visual inspections of histograms (see figure 4 for an example and Appendix 11 for all other figures) and boxplots were undertaken. The Visual and Oral Processing items showed a single outlier at the lower end of the spread (see figures 5-7 and Appendix 12 for all other figures). The Sensory Processing Related to Endurance/Tone Item showed multiple outliers at the lower end (see figure 7). Outliers were from different cases and data points did not fall into the extreme range. As such these were retained to ensure milder sensory needs were not excluded for the analysis therefore biasing the data. Assumptions of independent residuals, constant variance of residuals across scores of the predictor, and normally distributed residuals were met (see figures 8 and 9 for examples and Appendix 12 for all other figures).

Table 22. Kolmogorov-Smirnov Test (N = 21) for SPCQ Items

			Most Extreme Differences				
	Mean	(Std Dev)	Absolute	Positive	Negative	Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
Auditory Processing	25.86	(5.89)	0.11	0.09	-0.11	0.50	0.97
Visual Processing	36.57	(6.32)	0.23	0.15	-0.23	1.04	0.23
Vestibular Processing	46.14	(7.42)	0.21	0.14	-0.21	0.95	0.33
Touch Processing	77.19	(10.05)	0.21	0.12	-0.21	0.95	0.33
Multisensory Processing	27.33	(6.09)	0.20	0.12	-0.20	0.93	0.36
Oral Sensory Processing	49.14	(10.01)	0.15	0.14	-0.15	0.68	0.74
Sensory Processing Related to Endurance/Tone	38.90	(7.61)	0.21	0.21	-0.21	0.97	0.30
Modulation Related to Body Position and Movement	42.67	(6.04)	0.19	0.11	-0.19	0.85	0.47
Modulation of Movement Affecting Activity Level	24.95	(4.31)	0.16	0.16	-0.12	0.73	0.66
Modulation of Sensory Input Affecting Emotional Responses	15.52	(3.8)	0.20	0.12	-0.20	0.92	0.37
Modulation of Visual Input Affecting Emotional Responses and Activity Level	16.00	(2.85)	0.19	0.19	-0.14	0.86	0.45
Emotional/Social Response	63.48	(15.31)	0.24	0.16	-0.24	1.08	0.18
Behavioural Outcomes of Sensory Processing	22.52	(6.25)	0.19	0.12	-0.19	0.88	0.42
Items Indicating Thresholds for Response	12.48	(2.54)	0.25	0.16	-0.25	1.14	0.13

Table 23. Kolmogorov-Smirnov Test (N = 21) for SDQ

	Mean	(Std Dev)	Most Extreme Differences Absolute	Positive	Negative	Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
Emotional	2.76	(2.84)	0.26	0.26	-0.17	1.17	0.11
Conduct	2.33	(2.18)	0.19	0.19	-0.14	0.87	0.44
Hyperactivity	4.14	(3.37)	0.20	0.2	-0.16	0.94	0.35
Peer Relations	3.05	(2.84)	0.19	0.19	-0.14	0.89	0.41
Prosocial	6.76	(2.74)	0.18	0.18	-0.17	0.81	0.53
Total	12.29	(9.43)	0.17	0.17	-0.14	0.77	0.60
Externalising Scale	6.48	(5.19)	0.16	0.16	-0.14	0.71	0.69
Internalising Scale	5.81	(5.37)	0.18	0.18	-0.15	0.82	0.51

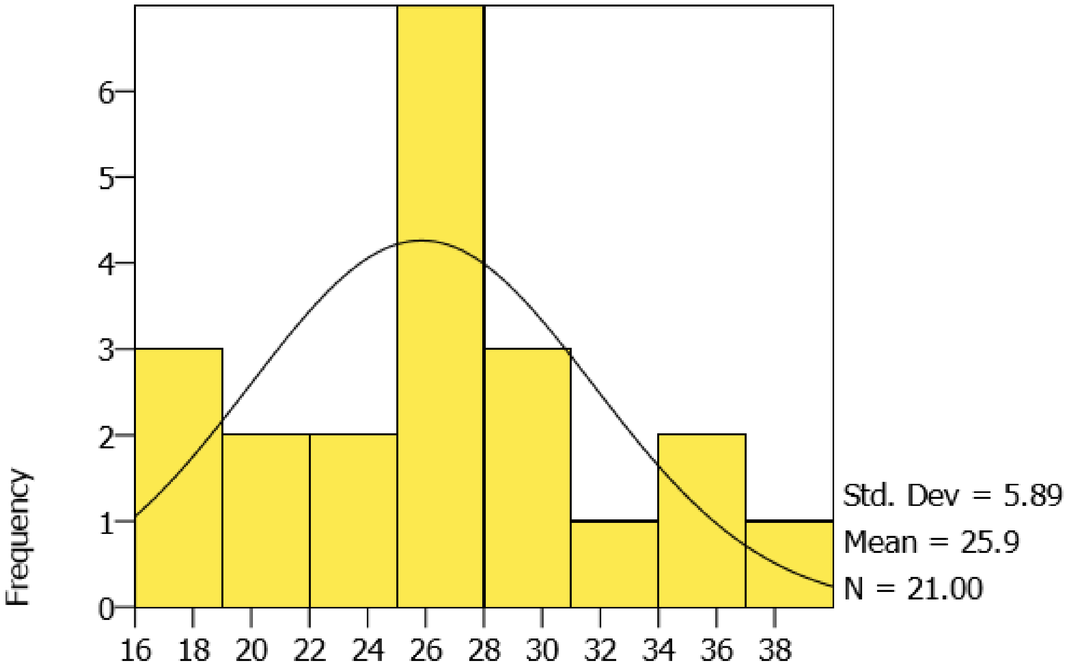
Table 23. Descriptive Statistics for SPCQ Items

	Mean (Std Dev)	Median	Range	Skew	Kurtosis
Auditory Processing	25.86 (5.89)	26	16 - 37	0.11	-0.36
Visual Processing	36.57 (1.38)	37	23 - 20	-1.57	2.54
Vestibular Processing	46.14 (7.42)	49	28 - 54	-1.16	0.48
Touch Processing	77.19 (10.05)	82	59 - 89	-0.52	-1.26
Multisensory Processing	27.33 (6.09)	30	16 - 35	0.65	-1.04
Oral Sensory Processing	49.14 (10.01)	51	29 - 60	-0.83	-0.40
Sensory Processing Related to Endurance/Tone	38.90 (7.61)	41	19 - 45	-1.59	1.92
Modulation Related to Body Position and Movement	42.67 (6.04)	45	30 - 50	-0.63	-0.67
Modulation of Movement Affecting Activity Level	24.95 (4.31)	24	17 - 33	0.26	-0.72
Modulation of Sensory Input Affecting Emotional Responses	15.52 (3.80)	16	9 - 11	-0.40	-1.25
Modulation of Visual Input Affecting Emotional Responses and Activity Level	16.00 (2.85)	16	12 - 20	-0.01	-1.48
Emotional/Social Response	63.48 (3.34)	70	35 - 80	-0.78	-0.95
Behavioural Outcomes of Sensory Processing	22.52 (6.25)	24	10 - 30	-0.71	-0.52
Items Indicating Thresholds for Response	12.48 (2.54)	14	6 - 15	-1.10	0.44

Table 25. Descriptive Statistics for SDQ Items

	Mean (Std Dev)	Median	Range	Skew	Kurtosis
Emotional	2.76 (2.84)	1	0 - 9	1.03	-0.17
Conduct	2.33 (2.18)	2	0 - 7	0.91	0.14
Hyperactivity	4.14 (3.37)	3	0 - 9	0.39	-1.36
Peer Relations	3.05 (2.84)	3	0 - 8	0.50	-0.83
Prosocial	6.76 (2.74)	7	2 - 10	-0.32	-1.46
Total	12.29 (9.43)	9	2 - 31	0.85	-0.49
Externalising Scale	6.48 (5.19)	5	0 - 16	0.48	-1.19
Internalising Scale	5.81 (5.37)	5	0 - 17	1.00	-0.12

Figure 4. Histogram of Auditory Processing



Figures 5-7. Boxplots of Visual, Oral, and Sensory Processing Related to Endurance/Tone

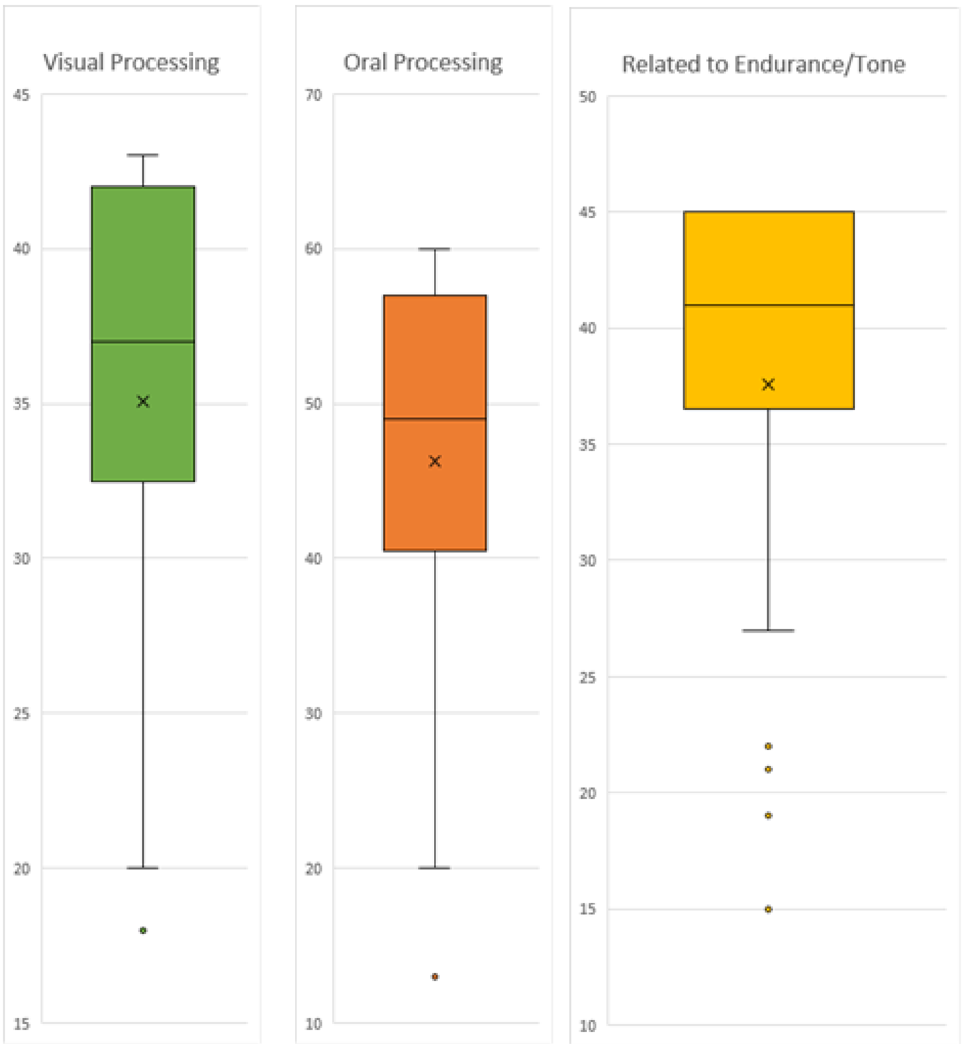


Figure 8. Auditory Processing Residual Plot

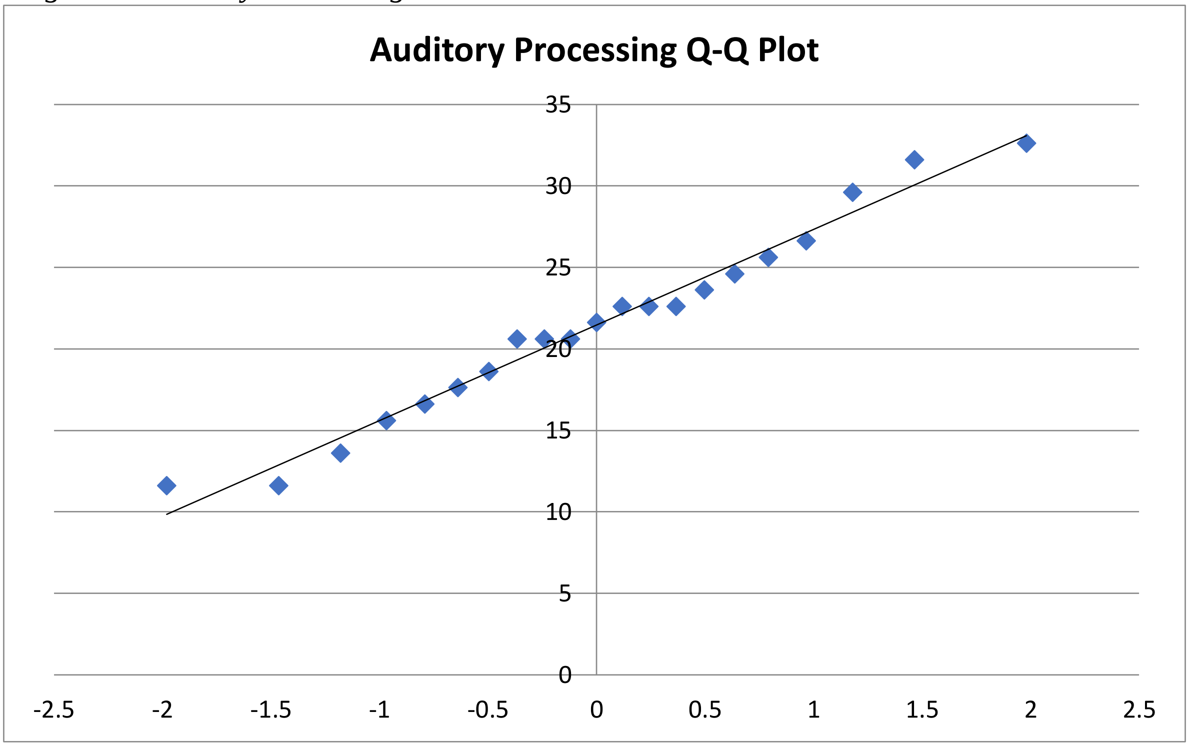
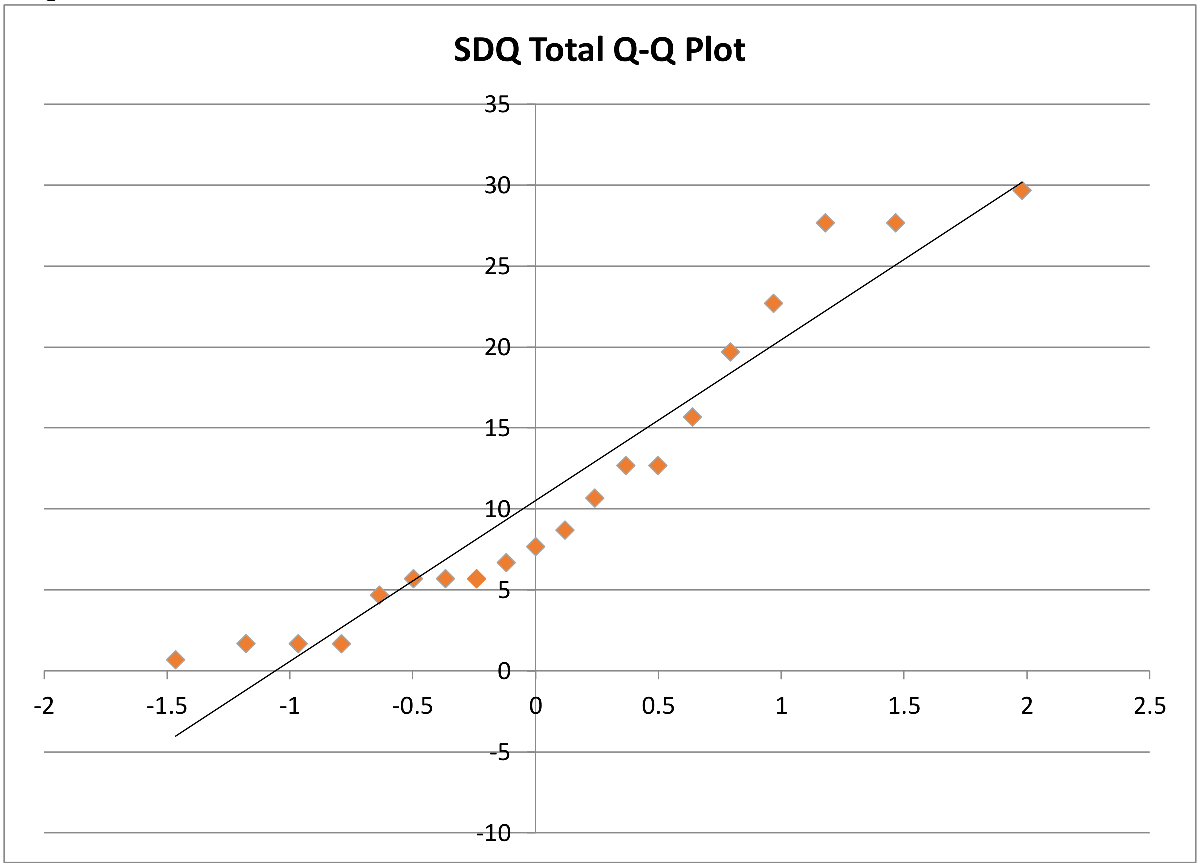


Figure 9. Total SDQ Score Residual Plot



Regression Statistics.

- **Total SDQ -** Sensory Processing scores explained a significant proportion of variance in the Total scale (R^2= 0.96, *F* (14, 6) = 9.28, *p* = < .01).
    - Increased Modulation of Movement Affecting Activity Level (β = 0.65, *p* = .04, 95%CI 0.06 – 2.81) and Visual Input Affecting Emotional Responses and Activity Level scores (β = 0.97, *p* = .02, 95%CI 0.84 – 5.58) significantly predicted an increase in Total scores.
    - Auditory, Visual, Touch and Multisensory Processing scores, and Emotional/Social Response scores also significantly predicted Total scores, however these had a 95% confidence interval including zero.
    - Behavioural Outcomes of Sensory Processing scores were borderline non-significant (*p* = .06) in predicting Total scores hinting at the possibility this would be significant in a larger sample.

  Tables for this model were included in the main text as an exemplar (see tables 26-28). Tables for other models are available in Appendix 14.

- **Emotional Scale -** A non-significant regression equation was found (R^2 = 0.78. *F* (14,6) = 1.55, *p* = .31)

- **Conduct Scale -** A non-significant regression equation was found (R^2 = 0.84, *F* (14, 6) = 2.18, *p* = .17).

- **Hyperactivity Scale -** Sensory Processing scores explained a significant proportion of variance in the Hyperactivity scale (R^2 = 0.92, *F* (14,6) = 5.08, *p* = .03)
    - Increased Visual (β = -2.04, *p* = .02, 95%CI -1.94 – -0.24) and Touch Processing (β = -2.11, *p* = .02, 95%CI -1.28 – -0.14),Modulation of Sensory Input Affecting Emotional Response (β = -1.52, *p* = .04, 95%CI -2.59 – -0.09), and Emotional/Social Response Responses (β = -1.08, *p* = .05, 95%CI -0.47 – -0.01) scores predicted lower Hyperactivity scores.
    - Increased Vestibular Processing scores (β =1.18, *p* = .02, 95%CI 0.14 – 0.92), Sensory Processing Related to Endurance/Tone (β = 0.72, *p* = .03, 95%CI 0.04 – 0.60) and Modulation of Visual Input Affecting Emotional Responses and Activity Level (β = 1.32, *p* = .02, 95%CI 0.43 – 2.68) predicted higher Hyperactivity scores.

Table 26. SDQ Total Score Item Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.98	0.96	0.85	3.62

Table 27. SDQ Total Score Item ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	1699.76	14	121.41	9.28	0.006
Residual	78.52	6	13.09		
Total	1778.29	20			

Table 28. SDQ Total Score Item Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
Constant	79.51	14.30	0.00	5.56	0.001	44.51	114.50
Auditory Processing	-1.13	0.43	-0.71	-2.61	0.040	-2.19	-0.07
Visual Processing	-2.03	0.73	-1.36	-2.76	0.033	-3.82	-0.23
Vestibular Processing	0.69	0.34	0.54	2.05	0.086	-0.13	1.51
Touch Processing	-1.41	0.49	-1.51	-2.88	0.028	-2.62	-0.21
Multisensory Processing	1.72	0.70	1.11	2.45	0.050	0.00	3.44
Oral Sensory Processing	0.05	0.32	0.06	0.16	0.877	-0.73	0.84
Sensory Processing Related to Endurance/Tone	0.24	0.24	0.19	0.99	0.359	-0.35	0.83
Modulation Related to Body Position and Movement	0.22	0.30	0.14	0.75	0.483	-0.51	0.96
Modulation of Movement Affecting Activity Level	1.43	0.56	0.65	2.55	0.044	0.06	2.81
Modulation of Sensory Input Affecting Emotional Responses	-1.66	1.08	-0.67	-1.55	0.173	-4.30	0.97
Modulation of Visual Input Affecting Emotional Responses and Activity Level	3.21	0.97	0.97	3.31	0.016	0.84	5.58
Emotional/Social Response	-0.94	0.20	-1.52	-4.74	0.003	-1.42	-0.45
Behavioural Outcomes of Sensory Processing	1.63	0.72	1.08	2.27	0.063	-0.12	3.39
Items Indicating Thresholds for Response	0.52	0.97	0.14	0.54	0.611	-1.86	2.90

- **Peer Relationships Scale –** A borderline non-significant regression equation was found (R^2 = 0.90, F (14, 6) = 3.67, p = .06). A similar analysis with a larger sample may produce a significant result in this area.

- **Prosocial Behaviour Scale -** Sensory Processing scores explained a significant proportion of variance in scores on the Pro-social Behaviour scale (R^2 = 0.92, F (14, 6) = 5.26, p = .03).
    - Increased Multisensory Processing (β = -2.35, p = < .01, 95%CI -1.71 – -0.40), Modulation of Movement Affecting Activity Level (β = -1.39, p = < .01, 95%CI -1.40 – -0.36), Modulation of Visual Input Affecting Emotional Responses (β = -0.95, p = .05, 95%CI -1.81 – -0.01) and Behavioural Outcomes of Sensory Processing scores (β = -1.92, p = .02, 95%CI -1.51– -0.17) significantly predicted increased Pro-social Behaviour scores.
    - Increased Auditory (β = 0.99, p = .03, 95%CI 0.06 – 0.86), Visual (β = 1.94, p = .02, 95%CI 0.16 – 1.52), Touch processing scores (β = 1.98, p = .03, 95%CI 0.08 – 1.00), and Emotional/Social Response (β = 1.89, p = < .01, 95%CI 0.16 – 0.52) significantly predicted increased Pro-social Behaviour scores.

- **Externalising Scales –**A borderline non-significant regression equation was found (R^2 = 0.89, F (14, 6) = 3.45, p = .07). A similar analysis with a larger sample may produce a significant result in this area.

- **Internalising Scales -** A non-significant regression equation was found (R^2 = 0.86, F (14, 6) = 2.55 p = .13).

Summary

- Sensory processing scores explained a significant proportion of variance in Total SDQ scores with the following variables significantly predicting scores:
  - Modulation Related to Body Position and Movement - ability to move effectively
  - Modulation of Visual Input Affecting Emotional Responses and Activity Level - ability to use visual cues to establish contact with others.
- Sensory processing scores explained a significant proportion of variance in scores on the Hyperactivity scale with the following variables significantly predicting scores:
  - Modulation of Visual Input Affecting Emotional Responses and Activity Level - ability to use visual cues to establish contact with others.
  - Visual Processing - responses to things which are seen
  - Vestibular Processing - responses to movement
  - Touch Processing - responses to stimuli that touch the skin
  - Sensory Processing Related to Endurance/Tone - ability to sustain physical performance
  - Modulation of Visual Input Affecting Emotional Responses and Activity Level - ability to use visual cues to establish contact with others
  - Emotional/Social Responses - psychosocial coping strategies.
- Sensory processing scores explained a significant proportion of variance in scores on the Pro-social scale with the following variables significantly predicting scores:
  - Auditory Processing - responses to things that are heard
  - Visual Processing - responses to things which are seen
  - Touch Processing - responses to stimuli that touch the skin
  - Multisensory Processing - responses to activities containing combined sensory experience
  - Modulation of Movement Affecting Activity Level - level of activeness
  - Modulation of Visual Input Affecting Emotional Responses and Activity Level - ability to use visual cues to establish contact with others.

Factor Regression.

For this regression, the dependent variables were the scales of the SDQ. The independent variables were Factor scores on the SPCQ. These were Sensory Seeking behaviour, Emotional Reactivity, Low Endurance/Tone, Oral Sensitivity, Inattention/Distractibility, Poor Registration [of sensory stimuli], Sensory Sensitivity, Sedentary [behaviour], and Fine Motor/Perceptual.

Descriptive Statistics.

One variable, Factor 7: Sensory Sensitivity, produced a borderline non-significant result (p = .06) on the Kolmogorov-Smirnov test of normality (see table 29). Skew and kurtosis were also once again computed (see table 30), revealing Sensory Sensitivity was not normally distributed (*Skew* = -1.71, *Kurtosis* = 3.18). Low Endurance/Tone (*Skew* = -1.59, *Kurtosis* = 1.92) and Poor Registration (*Skew* = -0.23, *Kurtosis* = -1.48) also appeared to be non-normally distributed (see table 29). In addition, visual inspections of histograms and boxplots for all variables were undertaken (see Appendices 11 and 12). Factor 3: Low Endurance/Tone, Factor 4: Oral Sensitivity, and Factor 7: Sensory Sensitivity showed outliers at the lower end of the spread (see figure 10 for an example, and Appendix 12 for all other figures). For the Factor analysis regression, the assumption of normally distributed residuals was not met (see figure 11 for an example and Appendix 13 for all other figures). As such, while the Factor analysis regression is presented for completeness, it must be considered with caution.

Table 29. Kolmogorov-Smirnov Test (N = 21) for SPCQ Factor Analysis

			Most Extreme Differences				
	Mean	(Std Dev)	Absolute	Positive	Negative	Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
Factor 1: Sensory Seeking	65.81	(13.03)	0.17	0.14	-0.17	0.77	0.59
Factor 2: Emotional Reactivity	57.43	(16.09)	0.21	0.15	-0.21	0.95	0.33
Factor 3: Low Endurance/Tone	38.90	(7.61)	0.21	0.21	-0.21	0.97	0.30
Factor 4: Oral Sensitivity	36.48	(8.43)	0.17	0.16	-0.17	0.79	0.56
Factor 5: Inattention/Distractibility	21.95	(5.7)	0.09	0.09	-0.07	0.43	0.99
Factor 6: Poor Registration	35.05	(3.9)	0.17	0.12	-0.17	0.77	0.60
Factor 7: Sensory Sensitivity	16.90	(3.88)	0.28	0.21	-0.28	1.27	0.06
Factor 8: Sedentary	13.81	(4.32)	0.12	0.12	-0.12	0.56	0.91
Factor 9: Fine Motor/Perceptual	12.14	(3.41)	0.20	0.2	-0.20	0.92	0.36

Table 30. Descriptive Statistics for Factor Analysis of the SPCQ

	Mean (Std Dev)	Median	Range	Skew	Kurtosis
Factor 1: Sensory Seeking	65.81 (13.03)	69	39 -80	-0.86	-0.40
Factor 2: Emotional Reactivity	57.43 (16.09)	63	29 -76	-0.75	-1.03
Factor 3: Low Endurance/Tone	38.90 (7.61)	41	19 - 45	-1.59	1.92
Factor 4: Oral Sensitivity	36.48 (8.43)	39	17 -45	-0.96	0.06
Factor 5: Inattention/Distractibility	21.95 (5.7)	22	12- 31	0.15	-0.74
Factor 6: Poor Registration	35.05 (3.9)	36	29 -40	-0.23	-1.48
Factor 7: Sensory Sensitivity	16.90 (3.88)	18	5 -20	-1.71	3.18
Factor 8: Sedentary	13.81 (4.32)	13	4 -20	-0.24	-0.20
Factor 9: Fine Motor/Perceptual	12.14 (3.41)	13	5 - 15	-1.13	0.15

Figure 10. Factor 3: Low Endurance/Tone Boxplot

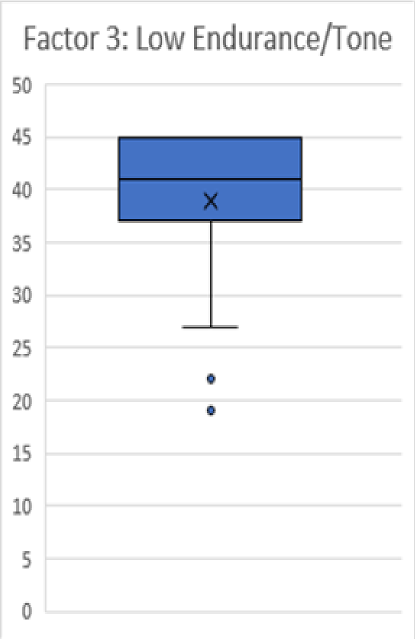
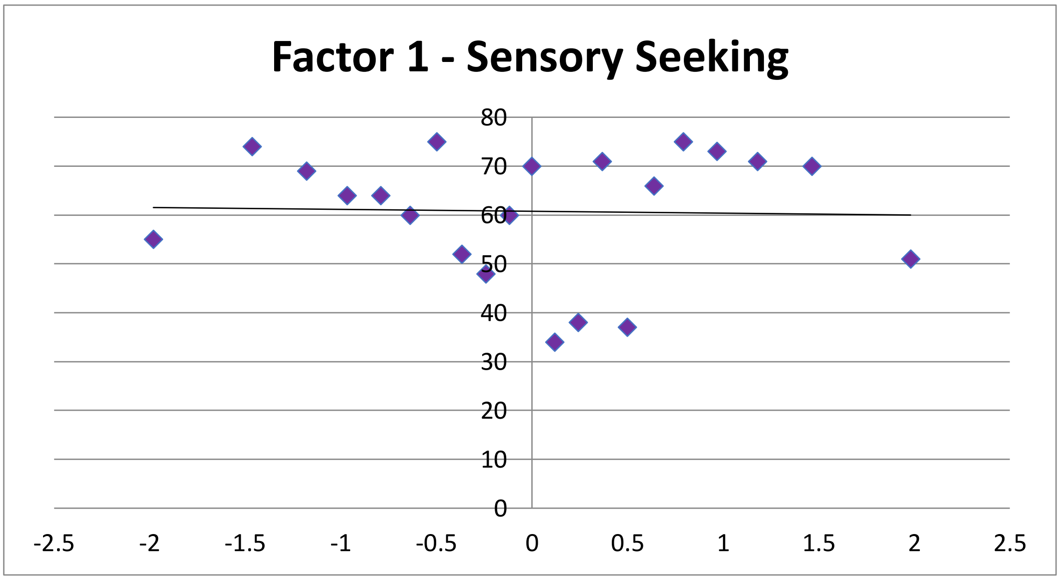


Figure 11. Factor 1: Sensory Seeking Residual Plot



Regression Statistics.

- **Total SDQ -** Sensory Processing scores explained a significant proportion of variance in scores on the Total scale (R^2 = 0.83, *F* (9, 11) = 6.10, *p* = <.01). No individual factor significantly predicted Total scores. Tables for this model were included in the main text as an exemplar (see tables 31-33). Tables for other models are available in Appendix 15.

- **Emotional Scale -** A borderline non-significant regression equation was found (R^2 = 0.72, *F* (9, 11) = 2.82, *p* = .06). A similar analysis with a larger sample may produce a significant result in this area.

- **Conduct Scale -** A non-significant regression equation was found (R^2 = 0.57, *F* (9, 11) = 1.49, *p* = .27).

- **Hyperactivity Scale -** Sensory Processing scores explained a significant proportion of variance in scores on the Hyperactivity scale (R^2 = 0.73, *F* (9, 11) = 2.95, *p* = .05). No individual factor significantly predicted Hyperactivity scores.

- **Peer Relationships Scale -** Sensory Processing scores explained a significant proportion of variance in scores on the Peer Relationship scale (R^2 = 0.79, *F* (9, 11) = 4.13, *p* = .02). No individual factor significantly predicted Peer Relationship scores.

- **Prosocial Behaviour Scale -** A non-significant regression equation was found (R^2 = 0.48, *F* (9, 11) = 1.01, *p* = .49).

- **Externalising Scale -** A non-significant regression equation was found (R^2 = 0.67, *F* (9, 11) = 2.30, *p* = .11).

- **Internalising Scale -** This scale is derived from the sum of the Emotional and Peer scale. Sensory Processing scores explained a significant proportion of variance in scores on the Internalising scale (R^2 = 0.78, *F* (9, 11) = 4.05 *p* = .02). No individual factor significantly predicted Internalising Scale scores.

- **Summary -** Sensory processing scores explained a significant proportion of variance in Total scores and scores on the Hyperactivity, Peer Relationships, and Internalising scales. For all three scales, no individual Factor significantly predicted scores

Table 31. SDQ Total Score Factor Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.91	0.83	0.70	5.2

Table 32. SDQ Total Score Factor ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	1481.29	9	164.59	6.10	0.003
Residual	297	11	27		
Total	1778.29	20			

Table 33. SDQ Total Score Factor Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
(Constant)	42.94	15.61	0.00	2.75	0.019	8.17	77.71
Factor 1: Sensory Seeking	-0.10	0.21	-0.16	-0.50	0.627	-0.56	0.36
Factor 2: Emotional Reactivity	-0.31	0.21	-0.54	-1.43	0.182	-0.78	0.17
Factor 3: Low Endurance/Tone	0.04	0.28	0.03	0.13	0.897	-0.59	0.67
Factor 4: Oral Sensitivity	-0.10	0.25	-0.10	-0.41	0.690	-0.67	0.46
Factor 5: Inattention/Distractibility	-0.40	0.38	-0.27	-1.05	0.318	-1.26	0.45
Factor 6: Poor Registration	0.41	0.66	0.19	0.62	0.552	-1.07	1.88
Factor 7: Sensory Sensitivity	0.02	0.45	0.01	0.04	0.965	-0.99	1.03
Factor 8: Sedentary	-0.26	0.49	-0.13	-0.53	0.609	-1.36	0.84
Factor 9: Fine Motor/Perceptual	-0.54	0.56	-0.22	-0.96	0.359	-1.79	0.71

Quadrant Regression.

A multiple linear regression was calculated to predict levels of mental distress based on sensory processing needs. The dependent variables were the scales of the SDQ. The independent variables were Quadrant scores on the SPCQ.

Descriptive Statistics.

Quadrant scores were normally distributed and produced non-significant results on the Kolmogorov-Smirnov test of normality (see table 34) with minor levels of Kurtosis on Sensation Seeking and Sensory Sensitivity (see table 35). A visual inspection of histograms and boxplots supported a normal disruption and there were no outliers (see figures 12 and 13 and Appendices 11 and 12 for all other figures). The assumptions of independent residuals, constant variance of residuals across scores of the predictor, and normally distributed residuals were met (see figure 14 for an example and Appendix 13 for all other figures).

Table 34. Kolmogorov-Smirnov Test (N = 21) for SPCQ Quadrant Analysis

			Most Extreme Differences				
	Mean	(Std Dev)	Absolute	Positive	Negative	Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
Quadrant 1: Low Registration	60.05	(10.03)	0.19	0.09	-0.19	0.86	0.45
Quadrant 2: Sensation Seeking	102.71	(19.63)	0.17	0.13	-0.17	0.77	0.59
Quadrant 3: Sensory Sensitivity	80.00	(11.66)	0.18	0.18	-0.18	0.84	0.49
Quadrant 4: Sensation Avoidant	112.81	(15.47)	0.15	0.12	-0.15	0.70	0.71

Table 35. Descriptive Statistics for Quadrant Analysis of the SPCQ

	Mean (Std Dev)	Median	Range	Skew	Kurtosis
Quadrant 1: Low Registration	60.05 (10.03)	63	41 - 75	-0.60	-0.68
Quadrant 2: Sensation Seeking	102.71 (19.63)	110	62 - 125	-0.82	-0.45
Quadrant 3: Sensory Sensitivity	80.00 (11.66)	84	61 - 94	-0.50	-1.40
Quadrant 4: Sensation Avoidant	112.81 (15.47)	116	85 - 137	-0.20	-1.13

Figure 12. Quadrant 1 Histogram

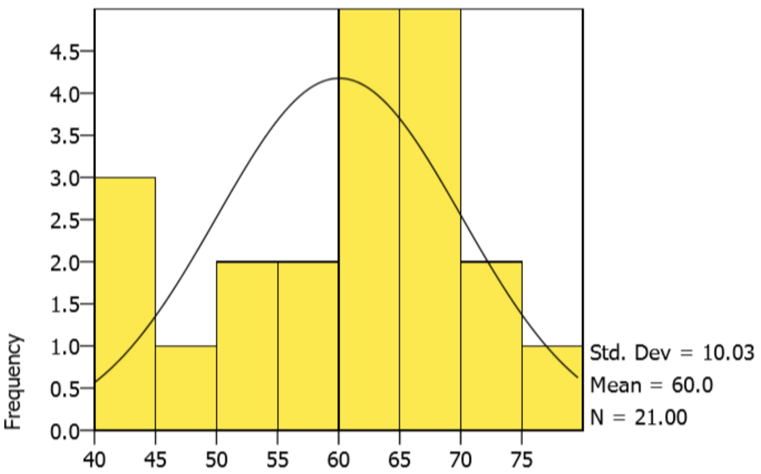


Figure 13. Quadrant Boxplot

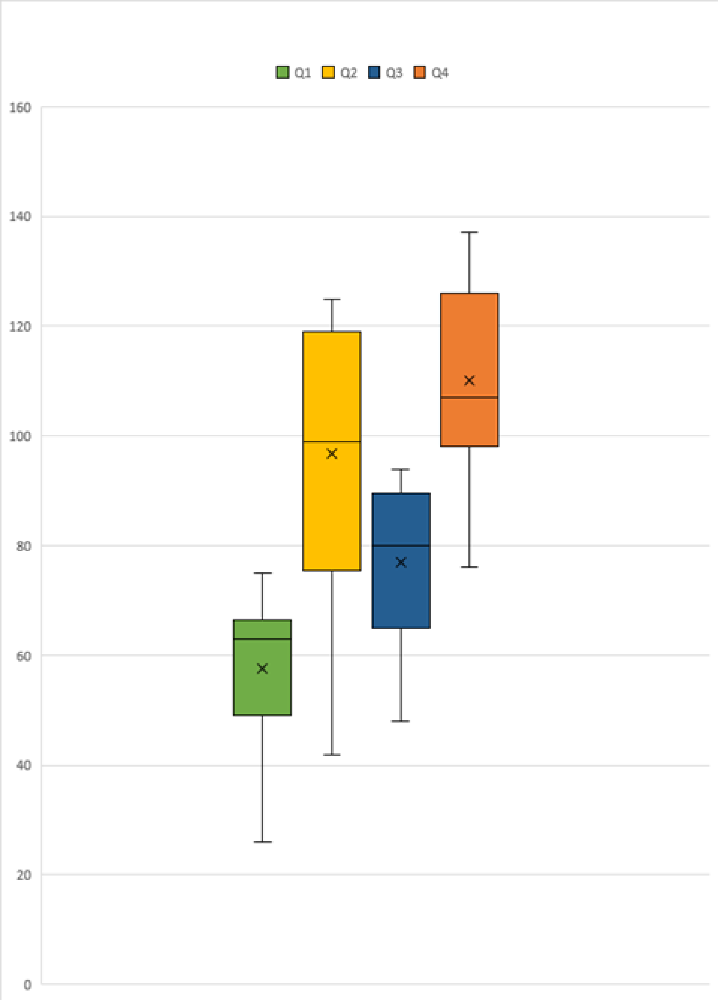
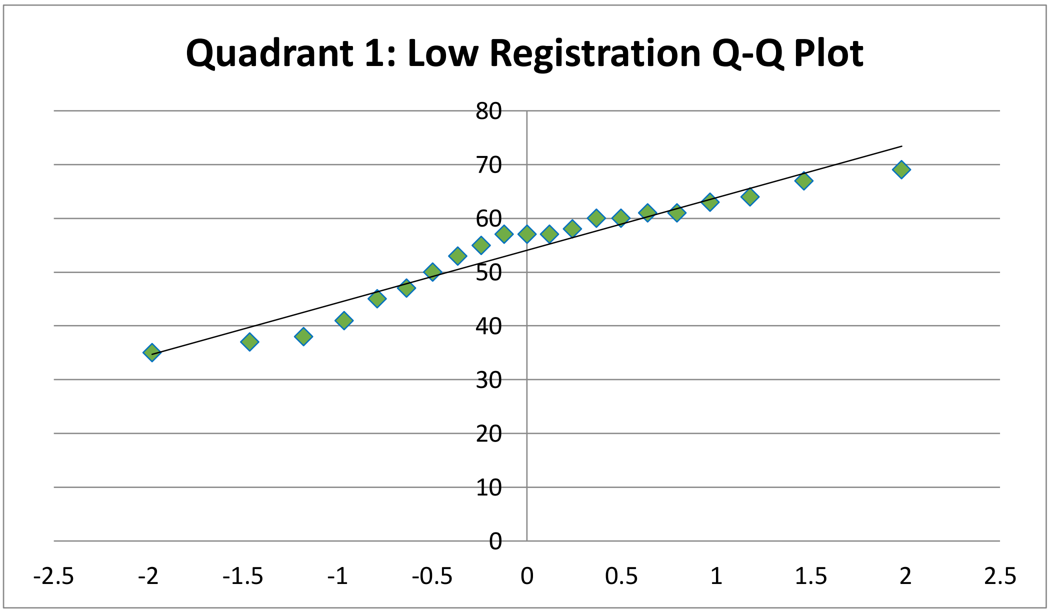


Figure 14. Quadrant 1 Residual Plot



Regression Statistics

- **Total SDQ Scores -**Sensory Processing scores explained a significant proportion of variance in scores on the Total scale (R^2 = 0.72, F (4, 16) = 10.21, p = <.001). No individual quadrant significantly predicted Total scores. Tables for this model were included in the main text as an exemplar (see tables 36-38). Tables for other models are available in Appendix 16.

- **Emotional Scale -** Sensory Processing scores explained a significant proportion of variance in scores on the Emotional scale (R^2 = 0.69, F (4, 16) = 8.78, p = .001). Increased Sensory Sensitivity (β = -0.61, p = .04, 95%CI -0.28 – -0.01) predicted lower Emotional scores.

- **Conduct Scale -** Sensory Processing scores explained a significant proportion of variance in scores on the Conduct scale (R^2 = 0.46, F (4, 16) = 3.44, p = .03). No individual quadrant significantly predicted Conduct scores.

- **Hyperactivity Scale -** Sensory Processing scores explained a significant proportion of variance in scores on the Hyperactivity scale (R^2 = 0.65, F (4, 16) = 7.48, p = .001). Increased Sensation Seeking (β = -0.74, p = .001, 95%CI -0.20 – -0.06) predicted lower Hyperactivity scores.

- **Peer Relationships Scale -** Sensory Processing scores explained a significant proportion of variance in scores on the Peer Relationship scale (R^2 = 0.68, F (4, 16) = 8.66, p = .001). No individual quadrant significantly predicted Peer Relationship scores.

- **Prosocial Behaviour Scale -** A non-significant regression equation was found (R^2 = 0.32, F (4, 16) = 1.85, p = .17).

- **Externalising Scale -** This scale is derived from the sum of the Conduct and Hyperactivity scale. Sensory Processing scores explained a significant proportion of variance in scores on the Externalising scale (R^2 = 0.57, F (4, 16) = 5.40, p = <.01). Increased Sensation Seeking (β = -0.63, p = <.01, 95%CI -0.28 – -0.05) predicted lower Externalising scores.

- **Internalising Scale -** This scale is derived from the sum of the Emotional and Peer scale. Sensory Processing scores explained a significant proportion of variance in scores on the Internalising Scale scores of the SDQ (R^2 = 0.74, F (4, 16) = 11.10, p = <.001). No individual quadrant significantly predicted Internalising scale.

- **Summary -** Sensory processing scores explained a significant proportion of variance in scores on Total scores and scores on the Emotional, Conduct, Hyperactivity, Peer, Externalising and Internalising scales. For all scales, no individual quadrant significantly predicted scores

Table 36. SDQ Total Score Quadrant Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.85	0.72	0.65	5.59

Table 37. SDQ Total Score Quadrant ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	1277.78	4	319.45	10.21	<0.001
Residual	500.50	16	31.28		
Total	1778.29	20			

Table 38. SDQ Total Score Quadrant Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
Constant	70.84	9.76	0.00	7.26	<0.001	50.16	91.52
Quadrant 1: Low Registration	-0.01	0.17	-0.01	-0.04	0.967	-0.37	0.35
Quadrant 2: Sensation Seeking	-0.17	0.08	-0.35	-2.10	0.052	-0.34	0.00
Quadrant 3: Sensory Sensitivity	-0.23	0.20	-0.28	-1.14	0.273	-0.66	0.20
Quadrant 4: Sensation Avoidant	-0.20	0.17	-0.32	-1.15	0.268	-0.56	0.17

Summary of Regression Analyses.

- In the Items regression sensory processing scores explained a significant proportion of variance in Total, Hyperactivity and Pro-social scores (see table 39).
- In the Factor regression sensory processing scores explained a significant proportion of variance in Total, Hyperactivity, Peer, and Internalising scores (see table 39).
- In the Quadrant regression sensory processing scores explained a significant proportion of variance in Total, Emotional, Conduct, Hyperactivity, Peer, Externalising, and Internalising scales (see table 39).

In all three analyses sensory processing scores explained a significant proportion of variance for Total SDQ scores. A significant proportion of variance in Hyperactivity and Peer relationship scores were explained by the Factor analysis of SPCQ. Sensory processing scores explained a significant proportion for most SDQ scales in the Quadrant analysis, only proving non-significant in the Pro-social scale. It is acknowledged that these regressions were undertaken with a small sample size, although one that is similar to previous sensory processing studies. As such, caution must be taken when interpreting the results. However, it is tentatively suggested that sensory processing needs may correlate with increased psychological distress in d/Deaf children. This could be of considerable clinical significance as d/Deaf children and young people are known to experience increased rates of psychological distress due to societal context. In keeping with the findings of previous research it is also further suggested that the Quadrant analysis may offer greater clinical insight than the Factor analysis.

Table 39. Proportion of Variance Explained by Individual SPCQ Variables for Each Significant Regression Equation

	Total		Emotional		Conduct		Hyperactivity		Peer		Pro-social		Externalising*		Internalising**	
	+β	-β	+β	-β	+β	-β	+β	-β	+β	-β	+β	-β	+β	-β	+β	-β
Item	Modulation Related to Body Position and Movement - *ability to move effectively*	*no -β*	*non-significant equation*		*non-significant equation*		Vestibular Processing - *responses to movement.*	Visual Processing - *responses to things which are seen.*	*non-significant equation*		Auditory Processing - *responses to things that are heard.*	Multisensory Processing - *responses to activities that contain a combined sensory experience.*	*non-significant equation*		*non-significant equation*	
	Modulation of Visual Input Affecting Emotional Responses and Activity Level - *ability to use visual cues to establish contact with others.*						Sensory Processing Related to Endurance/Tone - *ability to sustain physical performance.*	Touch Processing - *responses to stimuli that touch the skin.*			Visual Processing - *responses to things which are seen.*	Modulation of Movement Affecting Activity Level - *demonstration of activeness.*				
							Modulation of Visual Input Affecting Emotional Responses and Activity Level - *ability to use visual cues to establish contact with others.*	Modulation of Sensory Input Affecting Emotional Responses – *ability to use body senses to generate emotional responses.*			Touch Processing - *responses to stimuli that touch the skin.*	Modulation of Visual Input Affecting Emotional Responses and Activity Level - *ability to use visual cues to establish contact with others.*				
								Emotional/Social Responses - *psychosocial coping strategies.*			Emotional/Social Responses - *psychosocial coping strategies.*	Behavioural Outcomes of Sensory Processing - *ability to meet performance demands.*				
Quadrant	No specific Quadrant		*no +β*	Sensory Sensitivity	No specific Quadrant		*No positive Beta values*	Sensation Seeking	No specific Quadrant		No specific Quadrant		*no +β*	Sensation Seeking	No specific Quadrant	
Factor	No specific Factor		*non-significant equation*		*non-significant equation*		No specific Factor		No specific Factor		*non-significant equation*		*non-significant equation*		No specific Factor	

**Combined scores for conduct and hyperactivity scales*
*** Combined scores for emotional and peer scales*

Overall Summary of Results

Comparison of Sensory Profiles.

- 19 - 76% of scores for the d/Deaf sample fell outside of 'typical' ranges.
- Mean Item and Factors scores for the d/Deaf sample were lower than norms for typically developing children and higher than norms for children diagnosed with ASD or ADHD.
- There were statistically significant differences between d/Deaf children and norms for typically developing children on all Items, on 12 Items for children with a diagnosis of ASD, and 11 Items for children with a diagnosis of ADHD.
- There were statistically significant differences between d/Deaf children and typically developing children on three Factors, seven Factors for children with a diagnosis of ASD, and five Factors for children with a diagnosis of ADHD.

Degree of Hearing Loss, Equipment, and BSL Use.

- Equipment use significantly impacted scores for ability to sustain physical performance and low registration of sensory input with children using hearing aids showing greater levels of difficulties. No effect for degree of hearing loss or BSL use was found.

Sensory Processing and Mental Health.

- Scores for Items related to sensory processing, modulation, and behaviour explained a significant proportion of variance in Total, Hyperactivity and Pro-social scores.
- Factor scores explained a significant proportion of variance in Total, Hyperactivity, Peer, and Internalising scores. No individual Factors were significant for these scales.
- Quadrant scores explained a significant proportion of variance in Total, Emotional, Conduct, Hyperactivity, Peer, Externalising, and Internalising scores. Sensitivity to sensory input explained a significant proportion of variance in Emotional scores while seeking sensory input explained a significant proportion on Hyperactivity and Externalising scales.

It is tentatively suggested that d/Deaf children may have differing sensory profiles to both typically developing children and children with a diagnosis of ASD or ADHD and that sensory processing may be influenced by hearing equipment use. It is also suggested that sensory processing needs may correlate with increased psychological distress in d/Deaf children. This could be of considerable clinical significance given increased rates of mental health difficulties among d/Deaf children.

CHAPTER 5 - DISCUSSION

"Missing pieces do [not] complete the puzzle; they only fill an empty space" (Rice, 2020)

Discussion and Interpretation of Results

This study found a link between atypical sensory processing and increased scores related to psychological distress in a sample of 21 d/Deaf children as rated by their parents. While this sample size is not unusually small in context of studies exploring sensory processing (e.g. Van Der Linde (2003), N = 24; Kientz & Dunn (1997), N = 32; Brown et al., (2008), N = 26) caution must still be taken in the interpretation of these findings as a result of this limitation, particularly in light of the self-selecting nature of the sample. Furthermore, this study is the first of its kind and therefore necessitates greater levels of caution. Thoughtfulness must also be used in light of the complex picture that accompanies deafness such as delayed language acquisition, increased rates of attachment difficulties, and additional physical health and neurological diagnoses. The use of parent-rated measures of sensory processing and psychological wellbeing also necessitates some caution as it is acknowledged that parents sometimes perceive greater levels of difficulties than young people themselves do (e.g. van der Meer et al., 2008). However, the use of the SPCQ represents a clear strength in the current study as this measure is the gold standard in sensory processing assessment and is used clinically to inform interventions.

Sensory Processing Profiles: Response to Sensory Stimuli among d/Deaf Children.

In all sensory processing areas a proportion of the d/Deaf sample fell outside the 'typical' range. When children fall into the 'atypical' response range it indicates difficulties with processing sensory stimuli, suggesting a form of sensory stimuli could be confusing, upsetting, or not meaningful to a child, and could interfere with their abilities to complete tasks, tolerate certain environments, or engage with others. In all domains of sensory processing a large proportion of the d/Deaf sample demonstrated 'atypical' responses (see table 40). When reviewing figures in the d/Deaf sample it is important to remember that only 5-10% of the non-clinical hearing paediatric population are estimated to have 'atypical' responses to sensory stimuli.

Table 40. Categories of Response: Sensory Processing Domains

Area of Processing	'Atypical' Response	'Typical' Response
Auditory	76%	24%
Visual	38%	62%
Vestibular	43%	57%
Touch	38%	62%
Oral	43%	57%
Multisensory	48%	52%

Auditory Processing.

The cut offs used to define response 'ranges' are based on norms for hearing children and it is very unlikely these will accurately reflect the experiences of d/Deaf children, particularly in terms of auditory processing. In the current study 76% of the sample of d/Deaf children fell in the 'atypical' response range (see table 40). This was not surprising given 16 of the 21 children in the sample were listed as severe to profoundly deaf and we might therefore expect them to respond differently to auditory stimuli when compared with hearing children. No papers relating to auditory processing were found in the systematic literature review undertaken as part of the current project and as such only a limited consideration of the results of this study in the context of other work can be made. In their study exploring sensory processing in d/Deaf children with cochlear implants (N = 30) Bharadwaj et al. (2009) reported 'atypical' responses in different domains of sensory processing. Their highest reported level of 'atypical' responses was also in the auditory processing domain, although at considerably lower levels (40%). In the current study mean scores for cochlear implant and hearing aid users were on par (M = 27.9 and 24 respectively) and therefore this result cannot be attributed to cochlear implant use specifically; however it is possible the result could reflect deafness and use of hearing equipment in general. d/Deaf children are a varied and heterogeneous group and there are substantial barriers to making general statements based on the results of a single sample particularly when using hearing children as a reference group as research findings can be influenced by aetiology of deafness, levels of hearing loss, equipment use, language exposure, and numerous other factors.

Visual Processing.

Literature suggests no evidence for general enhancement of visual skills or lowered visual abilities in adulthood (Alencar et al, 2019; Bavelier et al., 2006). However, a body of research suggesting specific differences in visual processing between d/Deaf and hearing adults was found. d/Deaf people are thought to exhibit supranormal abilities compared to hearing controls in areas such as motion detection in peripheral vision, a lower threshold for detecting movement in general, and better performance in visuomotor synchronisation tasks (Bavelier et al., 2006; Iversen et al., 2015; Shiell et al., 2014). In contrast to adults d/Deaf children have shown lower scores on measures of visual perception compared to hearing controls until the age of approximately 10 years (Alencar et al., 2019). In the current study the visual processing domain had the lowest levels of 'atypical' responses across the sensory processing domains (39%) (see table 40). This is not an insubstantial figure, however changes in visual processing skills have also been attributed to use of sign languages (Alencar et al., 2019). Given the limited BSL skills among the parents of d/Deaf children in the sample it is possible older d/Deaf young people may show fewer or greater levels of differences in this area if they are exposed to more BSL as they grow.

Vestibular Processing.

Vestibular disorders are more prevalant among d/Deaf children however none of the children in the sample has such diagnosis. In addition, increased rates of postural and balance difficulties, and delayed motor skills have been found among d/Deaf children without vestibular disorder diagnoses (An, Yi, Jeon, & Park, 2009; Walicka-Cupryś et al., 2014; Ebrahimi, Movallali, Jamshidi, Rahgozar, & Haghgoo, 2017). In the current study roughly half the sample fell within the 'atypical' range (see table 40). It is possible that these findings are compatible as atypical sensitivity to bodily movements and where the body is in space may make it harder to balance and use the body.

Tactile Processing.

In the current study a third of the children scored in the 'atypical' response range (see table 40). The existing literature makes some suggestion of increased sensitivity to tactile stimuli among d/Deaf young people (Chakravarty, 1968; Levanen & Hamford, 2001; Schiff & Dytell, 1972) although this was not a uniform finding (Heming & Brown, 2005). There was also a suggestion that d/Deaf people may be more skilled in using and remembering information received through touch (Papagno et al., 2017). However, it must be acknowledged that patterns of behaviour associated with 'atypical' sensory processing are seen in the general population at large and it is thought to be the frequency or intensity of certain behaviours which are suggestive of difficulties that may impact on daily living and benefit from intervention (Ermer & Dunn, 1998). Further, the larger standard deviations in sensory processing scores for the d/Deaf sample compared with norms for typically developing children indicate there may be larger variations in sensory processing scores for children in the d/Deaf sample.

Oral Processing.

In the current study 43% of the sample of d/Deaf children fell in the ‘atypical’ response range (see table 40). No papers relating to oral processing were found in the systematic literature review undertaken as part of the current project. As such these results cannot be contextualised with other studies.

Overview of Processing.

Overall, the results of this study suggest the d/Deaf children in the sample largely respond to sensory stimuli in a ‘typical’ manner. However, in each area of sensory processing a considerable proportion of the sample fell outside of this range to demonstrate greater levels of ‘difficulties’ processing sensory stimuli (see table 41). This may be in line with previous literature suggesting differences in sensory processing needs among d/Deaf children when compared with hearing controls (Bharadwaj et al., 2009; Rhoades & Chisolm, 2001). The pattern of ‘atypical’ responses in the current study are also in keeping with Bharadwaj et al's (2009) study of sensory processing in d/Deaf children with cochlear implants (N = 30) although the current study indicated greater levels of ‘atypical’ responses in each domain (see table 41).

Table 41. Comparison of Percentage of d/Deaf Children falling in the ‘Atypical’ Response Range for Bharadwaj et al. (2009) and the current study (N = 30 and 21 respectively)

Area of Processing	Atypical Response	
	Current Study	*Bharadwaj et al, 2009*
Auditory	76%	40%
Visual	39%	10%
Vestibular	43%	40%
Touch	38%	25%
Oral	43%	25%

Modulation, and Behavioural and Emotional Responses

The Modulation items of the SPCQ reflect various combinations of sensory input which are part of daily life. As with items relating to individual areas of sensory processing scores outside of the ‘typical’ range indicates difficulties in a particular area. When a child has a ‘typical’ response in modulating sensory experiences they can organise input and generate appropriate responses while ‘atypical’ responses indicate difficulties. In the current study approximately half the d/Deaf sample fell within the ‘atypical’ response range in each area of modulation (see table 41). These results suggest a significant proportion of the d/Deaf children in the sample may experience difficulties beyond those of their hearing peers in relation to sitting still, remaining alert, and maintaining interaction with peers (Sensory Processing Related to Endurance/Tone), anticipating how to move around safely, incoordination, and clumsiness (Modulation Related to Body Position and Movement), regulating their activity levels in line with environmental demands (Modulation of Movement Affecting Activity Level), responding to social or environmental stimuli, becoming more inflexible or upset in situations than others (Modulation of Sensory Input Affecting Emotional Responses), and in understanding the usefulness of visual information resulting in inappropriate responses (Modulation of Visual Input Affecting Emotional Responses and Activity). This may be in line with previous literature suggesting difficulties pertaining to sensory organisation among d/Deaf children (Crowe & Horak, 1998). The Behavioural and Emotional Responses items of the SPCQ provide insight into emotional and behavioural responses to stimuli. In the current study approximately half the d/Deaf sample fell within the ‘atypical’ response range for psychosocial coping strategies and ability to meet performance demands. 20% of the sample fell within the ‘atypical’ response range for their ability to translate sensory information into behaviour matching the nature/intensity of sensory input (see table 42). These results suggest a significant proportion of the d/Deaf children in the sample may become more frustrated or easily upset by sensory stimuli (Emotional/Social Responses), struggle to complete tasks due to the impact of sensory input (Behavioural Outcomes of Sensory Processing), and/or have difficulty identifying relevant stimuli (Thresholds for Response). However, these behaviours may also be associated with other experiences of d/Deaf children such as the consequences of language deprivation. Furthermore, this data represents a pool of responses drawn for a sample of d/Deaf children. As such, while these results may indicate difficulties with sensory processing among the sample overall, it must be acknowledged that the patterns of behaviour associated with ‘atypical’ sensory processing are seen in the general populations at large and may not necessarily translate to clinical levels of need. This would need to be assessed on an individual basis as it is the frequency or intensity of behaviour which are significant in assessing for difficulties and would guide any clinically relevant interventions (Ermer & Dunn, 1998) (see Appendix 17).

Factors and Quadrant Responses.

The nine Factor scores can be used to gain an understanding of a child's thresholds and responsiveness to sensory events. In the current sample 71% of the children demonstrated 'atypical' responses in their abilities to concentrate and attend to input (Factor 5: Inattention/Distractibility) with approximately half noted to have 'atypical' responses with regards to their muscle tone and physical endurance (Factor 3: Low Endurance/Tone), sensory seeking behaviour (Factor 1: Sensory Seeking), engagement in sedentary activities (Factor 8: Sedentary) and emotional reactivity to sensory input (Factor 2: Emotional Reactivity) (see table 43). The four Quadrant scores can be used to quantify the degree to which a child may miss, obtain, detect, or be bothered by sensory input. Everyone engages in behaviours associated with each quadrant; they are separate but related concepts (The Psychological Corporation, 2003). For each Quadrant there is a separate continuum with scores on one end suggesting an individual may be impoverished in the characteristic and at the other end dominated by it. For example, the Sensory Sensitive and Low Registration quadrants do not represent two extremes of the same continuum; instead, they represent distinct sets of behaviour and necessitate differing intervention (The Psychological Corporation, 2003). In the current study approximately half the sample appeared likely to experience difficulties in each area (see table 43). Once again, the frequency or intensity of behaviour demonstrated by individuals would need to be assessed in order to ascertain whether these patterns represented clinically relevant difficulties and to determine interventions which could be offered (Ermer & Dunn, 1998). It is also important to bear in mind that factors such as language deprivation, difficulties with attachment, and the consequences of deafness have also been shown to lead to some of the behaviours described in the SPCQ (e.g. apparent inattention or distractibility could be related to a need for a greater number of breaks which is linked to the higher levels of concentration d/Deaf people need to exert in order to follow communication, or the repeating of information as a result of not hearing an instruction).

Table 42. Categories of Response: Modulation, and Behavioural and Emotional Responses

	'Atypical'	Typical
Sensory Processing Related to Endurance/Tone	38%	62%
Modulation Related to Body Position and Movement	48%	52%
Modulation of Movement Affecting Activity Level	48%	52%
Modulation of Sensory Input Affecting Emotional Responses	48%	52%
Modulation of Visual Input Affecting Emotional Responses and Activity	57%	43%
Emotional/Social Responses	43%	57%
Behavioural Outcomes of Sensory Processing	48%	52%
Thresholds for Response	29%	71%

Table 43. Categories of Response: Factor and Quadrant

	'Atypical'	Typical
Factor 1: Sensory Seeking	57%	43%
Factor 2: Emotional Reactivity	43%	57%
Factor 3: Low Endurance/Tone	62%	38%
Factor 4: Oral Sensitivity	33%	67%
Factor 5: Inattention/Distractibility	71%	29%
Factor 6: Poor Registration	33%	67%
Factor 7: Sensory Sensitivity	29%	71%
Factor 8: Sedentary	48%	52%
Factor 9: Fine Motor/Perceptual	19%	81%
Quadrant 1: Low Registration	67%	33%
Quadrant 2: Sensation Seeking	48%	52%
Quadrant 3: Sensory Sensitivity	43%	57%
Quadrant 4: Sensation Avoidant	41%	48%

Sensory Processing Profiles: Comparison with Other Groups.

The current study excluded d/Deaf children with diagnoses of ASD and ADHD, two diagnoses linked with additional sensory processing needs. This was necessary in order to account for possible extraneous variables in the analysis. However, there are considerably higher rates of these diagnoses with the d/Deaf population compared with their hearing peers. In part this is related to the effects of language deprivation however both diagnoses also make reference to sensory processing needs and/or behaviour associated with these. In the current study mean scores for the d/Deaf sample were lower than norms for typically developing children and higher than norms for children diagnosed with ASD or ADHD. There were statistically significant differences between scores for d/Deaf children and norms for typically developing children, and between scores for d/Deaf children with a diagnosis of ADHD. This suggests differences in sensory processing profiles between d/Deaf children and typically developing children, and between d/Deaf children a diagnosis of ASD or ADHD. These results potentially suggest greater levels of sensory processing needs among typically developing d/Deaf children when compared to hearing peers and that caution is required when using sensory processing needs as indicators for diagnosing neurodevelopmental disorders among d/Deaf children.

Degree of Hearing Loss, Equipment, and BSL Use.

No effect of degree of hearing loss or BSL use on sensory processing was found. Equipment use was found to have a large impact on a child's ability to sustain physical performance and registration of sensory stimuli with children using hearing aids showing greater levels of difficulties than those using cochlear implants. Given limitations in the sample size of the current study and research regarding sensory processing among d/Deaf children these results are difficult to interpret. The only previous study exploring sensory processing among cochlear implant users did not report on the modulation items or quadrants of the SPCQ (Bharadwaj et al., 2009). Hearing aids work by amplifying sound whereas cochlear implants are used to bypass the damaged parts of the cochlea and directly stimulate the auditory nerve. Using hearing aids does not restore 'normal' levels of hearing and common problems with using them can include unwanted feedback noises and the amplification of background noise as well as sounds a person may wish to focus on. That is not to imply that using a cochlear implant leads to 'normal' hearing either[10]. Furthermore,

[10] To gain a sense of what it is like to hear using a cochlear implant, hearing people can listen to clips of vocoded speech on YouTube. Such clips are often used in research settings to simulate cochlear implant use for hearing research participants (e.g. Cardin et al, 2020).

cochlear implants are not suitable for all aetiologies of deafness. Nonetheless, improved registration of sensory stimuli among cochlear implant users could be explained if it were underpinned by higher scores on auditory processing items; however, this was not the case in the current sample. The impact of aetiology of deafness or duration of implantation were not analysed due to limitations related to sample size. More research will be needed to make sense of these results.

Sensory Processing and Mental Health.

Overall Levels of Difficulties.

On the Emotional, Conduct, Hyperactivity, Prosocial, and Total scales of the SDQ the majority of young people in the current sample scored in the 'normal' range; however, approximately one quarter to one third of the young people also scored in the 'abnormal' range for the Emotional, Conduct, Prosocial, and Total scales. For the Peer Problems scales all the young people scored in the 'abnormal' range. This could suggest significant difficulties for a sizable portion of the d/Deaf children in this sample despite using a non-clinical sample.

Emotional Difficulties.

Increased sensitivity to sensory stimuli was linked with greater emotional distress. Theoretically, children with sensory sensitivity experience low thresholds for stimuli experiencing discomfort associated with this and employing a passive behaviour strategy. These children may be seen as precise or picky which may be interpreted as indications of anxiety or low mood as measured by the SDQ (e.g. items associated with somatisation, tearfulness, or nervousness/fearfulness). Literature available on sensory processing and mental wellbeing in d/Deaf children was limited in scope and primarily focused on motor development. However, within the literature there were some indications that lower levels of balance and motor skills were linked with increased difficulties in peer relationship and increased emotional difficulties among d/Deaf children and young people (6-16 years) (Fellinger et al, 2015). The current results do not support this suggestion however, as noted, this study had a smaller sample (N = 21) than Fellinger et al. (2015) (N = 93).

Hyperactivity.

Increased response to movement, and an increased ability to sustain physical performance and establish contact with others using visual cues were linked with increased hyperactivity, indicating greater levels of difficulty. Lower response to visual and tactile stimuli, a lowered ability to use bodily senses to generate emotional responses, and fewer psychosocial coping strategies were also linked with increased levels of hyperactivity. Lower scores for sensory seeking behaviour were also linked to increased hyperactivity (see table 44). The SDQ is a screening measure which taps into multiple dimensions associated with distress in children and young people. The hyperactivity scale covers attention, impulsivity, and activity level however sensory seeking behaviour is associated with attention difficulties and not necessarily impulsivity and increased activity levels. This may suggest attentional difficulties which are being captured by this result (e.g. lower response to visual and tactile stimuli because the child does not attend to them). This idea was supported by high rates of 'atypical' responses on the inattention/distractibility (71% of the sample) factor analysis but it is possible that this is a reflection of the effects of language deprivation and/or the natural consequences of deafness as well as, or instead of, any sensory processing needs.

Prosocial Behaviour.

Decreased responses to auditory, visual, and tactile stimuli, and decreased psychosocial coping strategies were linked with lower pro-social behaviour scores, indicating greater levels of difficulty. Lowered response to multiple sensory stimuli, lower activeness, and decreased ability to establish contact with others using visual cues and meet performance demands were also linked with decreased pro-social behaviour scores (see table 45). Literature available on sensory processing and mental wellbeing in d/Deaf children did not explore pro-social behaviour as a measure of wellbeing.

Table 44. Impact of Sensory Processing on Hyperactivity

Increased Hyperactivity Score
Increased response to movement
Increased ability to sustain physical performance
Increased ability use visual cues to establish contact with others
Decreased response to visual stimuli
Decreased response to tactile stimuli
Decreased ability to use bodily sense to generate emotional responses
Less sensory seeking behaviour

Table 45. Impact of Sensory Processing on Pro-social Behaviour

Decreased Prosocial Behaviour Score
Decreased response to auditory stimuli
Decreased response to visual stimuli
Decreased response to tactile stimuli
Decreased psychosocial coping strategies
Increased response to combined stimuli
Increased activeness
Increased ability to use visual cues to meet performance demands
Increased sensory sensitivity

Conduct and Peer Relationships.

There was a suggestion that sensory processing Quadrant scores were linked to scores on the Conduct scale of the SDQ. However, no individual Quadrant demonstrated a statistically significant link. There was also a suggestion that sensory processing Quadrant scores and sensory processing Factors were both linked to scores on the Peer Relationships scale of the SDQ. No individual Quadrant or Factor demonstrated a statistically significant link however as this study had a smaller sample size[11] and was conducted with a non-clinical sample it is possible this represents a false negative (see Appendix 18).

Coulda, Woulda, Shoulda: Beneficial Changes and Future Commitments.

If this project were repeated several changes could be made to mitigate some of limitations of the current work. The first would be to ensure that early recruitment did not neglect the parents of hearing children. While data from the parents of hearing children was collected the planned analysis required hearing children to be age and gender matched with d/Deaf children. This substantially limited the amount of data from the parents of hearing children which could be used. This requirement alongside the decision to suspend recruitment due to the Covid-19 pandemic meant an additional planned analysis could not be undertaken. Over a nine-month period, 67 schools and organisations were contacted as part of the recruitment for this study (see Appendix 3). The majority of these were local and national organisations supporting d/Deaf children and their families, and schools with d/Deaf pupils. More schools without d/Deaf students should have been contacted to facilitate recruitment of parents of hearing children. Despite recruitment efforts focusing on the parents of d/Deaf children it must be acknowledged that final d/Deaf sample size was small (although not usual for studies exploring sensory processing) limiting the power of analyses, internal and external validity, and generalisability of results. It is possible this low response rate reflects a limited awareness of the impact of sensory processing needs among the parents and educators of d/Deaf children (similar to the diagnostic overshadowing of deafness sometimes seen among children with ‘missed’ diagnoses of ASD or ADHD wherein behaviour or challenges are perceived as the consequences of d/Deafness). This in turn could be due to the limited engagement of researchers in this area. On a practical level a lack of awareness could be addressed by activities aiming to educate families and organisations about sensory processing needs (e.g. offering training to teachers, speaking at third sector events). However, there are a

[11] *Power calculations suggests 59 - 91 participants are needed to detect large effect sizes with 934 – 1373 for small effect sizes dependent on which method of analysis is used for the SPCQ data (see Appendix 18).*

number of ethical and methodological concerns that would need to be adequately addressed prior to any such undertaking; especially if they were linked with research activities (e.g. potentially priming parents or educators to view behaviour with a 'sensory' lens therefore biasing results, or possible distress or harm this may cause to a young person or their family). It is also possible the surveys used in the current project were not as accessible to the parents of d/Deaf children as it was first thought they would be. There was a 53% attrition rate in the current survey which may have introduced some bias into the results. For example, the SPCQ is a long questionnaire (125 items) which may have resulted in disengagement by parents who did not strongly feel that their child is distressed by sensory stimuli. Previous studies have also suffered from low return rates when using the SPCQ (e.g. van der Linde et al., 2013) and this may suggest that questionnaire is not generally accessible. The decision to use written English questionnaires was made on the basis that 90% of d/Deaf children are born to hearing parents who would therefore be able to access written English. However, one Headteacher supporting recruitment disclosed that approximately two thirds of families with children enrolled at the school did not use English as a first language at the home (personal correspondence, 20th November 2019). This may be related to the school's location but it is an important piece of feedback for any future research: for example, this may suggest researchers might be better off conducting in-person assessments rather than using internet-based surveys with this population of parents. Conducting in-person assessments would have the advantage of allowing for Deaf parents to take part in the study if funding for an interpreter was available. If additional funding were available, it would also be valuable to recruit an Occupational Therapist with experience in assessing sensory processing to the research team. This would allow research activities to expand into areas such as behavioural observations. The current work could also be expanded into a consideration of sensory processing among d/Deaf people across the lifespan in light of suggestions that sensory processing needs in adult populations may reflect those seen in childhood, and the lifelong impacts of these needs. This may include a series of cross-sectional studies or even longitudinal pieces of work. For adolescents and adults this would also mean that self-rated data could be collected as the current study uses parent reported data and it is generally accepted that parents report greater levels of difficulties than their young people. It would also be interesting to undertake qualitative work, such as interviews with d/Deaf children, young people, and adults with the aim of understanding their experiences of sensory processing. Such studies could be based on similar studies undertaken with people with a diagnosis of ASD. The current study was also limited to a non-clinical sample of d/Deaf children. Future studies could explore sensory processing needs among d/Deaf children with additional needs such as those with neurodevelopmental or mental health diagnoses. It could also be used to account for the impact of other risk factors associated with sensory processing needs such as premature birth and attachment styles. This could be undertaken in partnership with Deaf mental health services such as SignHealth or Deaf4Deaf (third sector adult services) and National Deaf CAMH services (NDCAMHS). This would also allow research to address and explore professional viewpoints and perspectives (e.g. through clinician-rated measures or interviews), while also allowing for analyses of individual case studies. The current project team have made commitments to explore these ideas further and consider applying for research grants to expand on the current work.

Clinical Implications

Behaviour associated with sensory processing needs can also arise from language deprivation, attachment difficulties, adverse life experiences, and unjust sociocultural structures. d/Deaf children are more at risk of delayed access to language, childhood trauma, disrupted attachment, structural inequalities, and marginalisation and discrimination. Sensory processing needs also form part of the clinical presentation of other psychiatric diagnoses such as ASD and ADHD; both of which are diagnoses at higher rates in d/Deaf children and young people. Clinicians working in specialist d/Deaf services therefore become skilled at considering and thinking around different aspects of a young person's experiences. A key component of this is adopting a transdiagnostic and holistic perspective. In contrast to a diagnostic classification system which implies each "disorder" requires its own specific form of treatment, a transdiagnostic perspective holds common mechanisms underlie differing manifestations of distress or difficulties, and suggests a more finely-grained etiologic and phenomenological descriptions may better guide effective clinical practice compared with treatment based on discrete diagnostic categories. As such, during assessments, formulation, and intervention activities with d/Deaf young people consideration should be given to the high probability of delayed language acquisition, family dynamics, social isolation, issues of ablism such as parents having lower expectations for their child's future because of their deafness and issues of identity related to disability or cultural perspectives of d/Deafness, possible disruptions of attachment, the impact of past physical illness (e.g. potential cognitive impacts of meningitis, rubella, or measles which can be a cause of deafness) and current comorbid physical health needs, and barriers to education and leisure activities all of which impact of socioemotional development and psychological wellbeing. However, it is not only clinicians within d/Deaf services that need to have knowledge around mental health and d/Deafness. The d/Deaf population are geographically spread. This makes setting up specialist services problematic, complicated further by structural barrier to accessing funding. At present only secondary and tertiary services are recognised as “specialist” and therefore eligible for ring-fenced funding. As such many d/Deaf people rely on accessing hearing services. While this remains the case, improved awareness and training for mental health practitioners is vital. However, an as-yet unpublished study by the lead author of this paper which audited teaching on d/Deafness and mental health on UK clinician and forensic psychology trainees suggested little-to-no training is provided (Coulson-Thaker & Coxell, unpublished). As such it seems likely that clinicians meeting with a Deaf client for the first time will be largely unaware of the complexities of working with Deaf clients, the barriers to they may experience and how to minimise these, the roles of cultural and language in assessment and treatment of these individuals, and the legal and ethical implications of working with this group. Specific training and education around the complexities of working with d/Deaf people across the lifespan within psychology courses is long overdue.

Conclusion

The current study suggests sensory processing among d/Deaf children may represent a unique pattern that differs from typically developing children and children with neurodevelopmental diagnoses. It also suggests d/Deaf children may experience more difficulties in processing, using, and responding to sensory stimuli than their hearing peers, and that there is a possible link between psychological distress and sensory processing needs among d/Deaf children. The impact of degree of hearing loss, aetiology of deafness, equipment or BSL use on sensory processing, if any, remains unclear due to limitations in the analyses that could be undertaken based on the current sample size and demographics. Considerable caution is needed when considering the findings of this study and their clinical applications. The study has a small sample size and it is recognised that d/Deaf children are a varied and heterogeneous group where the individual differences can be considerable. As such generalizability is limited for this study. There are substantial, interwoven levels of complexity which need to be adequately accounted for before any definite comment on sensory processing among this group of children can be made. Given these complexities, qualitative and case studies as well as more quantitative research exploring the impact of sensory processing in both clinical and non-clinical populations of d/Deaf people across the lifespan may be of considerable benefit.

Overall Summary and Recommendations

This study explored sensory processing in five to 10 year old d/Deaf children. d/Deaf people experience at least one sensory input (auditory stimuli) differently to the general population, with research suggesting differences in multiple of sensory processing domains. There are also links between deafness and risk factors associated with increased levels of sensory processing needs. Children with sensory processing needs can show decreased social skills, experience lower levels of self-confidence, self-esteem, and academic success, and experience difficulties in activities of daily living and higher rates of mental health difficulties. d/Deaf children and young people are at a high risk of mental health difficulties than their hearing peers due to multiple factors. To date d/Deaf children and young people have been excluded from research into sensory processing and the effectiveness of interventions for these. The current study was the first of its kinds and it is essential this work is built on in order to develop a understanding of sensory processing among d/Deaf children, how these affect children at home, school, and during leisure activities, and the impact they have on mental wellbeing. Larger studies and more varied forms of research will be necessary. Future studies in this area could include:

- Quantitative studies with larger samples, directly comparing d/Deaf children with other groups of children, and accounting for other diagnoses and risk factors associated with increased sensory processing needs;
- Qualitative studies exploring the impact of sensory processing from the perspectives of both d/Deaf young people and their families;
- Mixed methods and multidisciplinary research (e.g. combining OT behavioural; observations with parent-rated measures of sensory processing and interviews with d/Deaf children and their families focusing on the impact of sensory processing on mental wellbeing);
- Further exploration of factors which may impact sensory processing among d/Deaf children (e.g. hearing equipment and signed language proficiency, and degree and aetiology of deafness);
- Research which includes clinical populations such as children under the care of NDCAMHS;
- Explorations of professional perspectives on working with d/Deaf children in the context of sensory processing needs in educational and clinical settings;
- Detailed case studies about specific d/Deaf children with sensory processing needs

- Explorations of the impact of sensory processing needs among d/Deaf children in educational settings;
- The development of assessments and interventions for d/Deaf children who experience difficulties with sensory processing, and interventions for the impact these needs may have on their mental wellbeing;
- Studies into sensory processing needs among d/Deaf people and their impact across the lifespan.

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TABLE OF APPENDICIES

Appendix 1 –Search Terms with Number of Papers Generated 118
Appendix 2 - Papers Identified in the Sensory Processing Review by Sensory Area 121
Appendix 3 – Ethical Approval 126
Appendix 4 –Information Sheet and Consent Form 129
Appendix 5 – Recruitment Information 133
Appendix 6 - Recruitment Sites 134
Appendix 7 - SDQ – Parent Report 136
Appendix 8 - Extract From SPCQ 137
Appendix 9 – SPCQ Technical Report 138
Appendix 10 – One Sample T-Test Results 142
Appendix 11 – Histograms 144
Appendix 12 – Boxplots 157
Appendix 13 – Q-Q Plots 162
Appendix 14 – Tables for Items Regression Model 175
Appendix 15 – Tables for Factor Regression Models 183
Appendix 16 – Tables for Quadrant Regression Models 191
Appendix 17 – Example of a Clinical Interpre Appendices, tation of the SCPQ 199
Appendix 18 – A Prior Power Plots 203

Appendix 1 –Search Terms with Number of Papers Generated

Sensory Processing		Deaf
Sensory Processing	*AND*	Deaf

Title, abstract, key word search	
PubMed	0
Scopus	401
Cochrane	1
Total	**402**

All fields search	
PubMed	13
Scopus	401
Cochrane	1
Total	**415**

Sensory Processing		Deaf
Sensory Sensory processing Sensory processing dysfunction	*AND*	Deaf

Title, abstract, key word search	
PubMed	14
Scopus	569
Cochrane	14
Total	**596**

All fields search	
PubMed	879
Scopus	1,239
Cochrane	14
Total	**2,132**

Sensory Processing		Deaf		Mental Health
Sensory Sensory processing Sensory processing dysfunction Vestibular Oral Auditory	*AND*	Deaf hearing impair* hearing loss hard of hearing d/deaf deaf*	*AND*	Mental Health Wellbeing Well-being Quality of Life Depress* Anxi*

Title, abstract, key word search	
PubMed	1
Scopus	2,067
Cochrane	6
Total	**2,074**

All fields search	
PubMed	10,634
Scopus	3,485
Cochrane	6
Total	**14,125**

Sensory Processing		Deaf
Sensory Sensory processing	*AND*	Deaf hearing impair*

Sensory processing dysfunction		hearing loss hard of hearing d/deaf deaf*

Title, abstract, key word search	
PubMed	1
Scopus	9,450
Cochrane	14
Total	**9,465**

All fields search	
PubMed	6,438
Scopus	9,450
Cochrane	14
Total	**15,902**

Sensory Processing		**Deaf**
Sensory		Deaf
Sensory processing		hearing impair*
Sensory processing dysfunction	*AND*	hearing loss
Vestibular		hard of hearing
Oral		d/deaf
Auditory		deaf*

Title, abstract, key word search	
PubMed	265
Scopus	65,874
Cochrane	17
Total	**66,156**

All fields search	
PubMed	6,438
Scopus	65,874
Cochrane	17
Total	**72,329**

Appendix 2 - Papers Identified in the Sensory Processing Review by Sensory Area

MOTOR			
Author	Title	Year	Found
Dummer, Haubenstricker, & Stewart	Motor skill performances of children who are deaf	1995	An et al, 2009
Levesque, Theoret, & Champoux.	Reduced procedural motor learning in deaf individuals	2014	PubMed
Rine, Cornwall, Gan, LoCascio, O'Hare, & Robinson	Evidence of progressive delay of motor development in children with sensorineural hearing loss and concurrent vestibular dysfunction	2000	An et al, 2009
Suarez, Alonso, Arocena, Ferreira, Roman, Suarez, & Lapilover	Sensorimotor interaction in deaf children. Relationship between gait performance and hearing input during childhood assessed in pre-lingual cochlear implant users	2017	PubMed

OLFACTORY			
Author	**Title**	**Year**	**Found**
Guducu, Oniz, Ikiz, & Ozgoren	Chemosensory Function in Congenitally Blind or Deaf Teenagers	2016	PubMed

TOUCH			
Author	**Title**	**Year**	**Found**
Heimler & Pavani	Response speed advantage for vision does not extend to touch in early deaf adults	2014	Cochrane
Papagno, Minniti, Mattavelli, Mantovan, & Cecchetto	Tactile short-term memory in sensory-deprived individuals	2017	PubMed

VESTIBULAR			
Author	**Title**	**Year**	**Found**
An, Jeon, & Park	Age-related changes of single-limb standing balance in children with and without deafness	2009	PubMed
de Sousa, de França Barros, & de Sousa Neto	Postural control in children with typical development and children with profound hearing loss	2012	PubMed
Ebrahimi, Movallali, Jamshidi, Rahgozar, & Haghgoo	Postural control in deaf children	2017	PubMed
Selz, Girardi, Konrad, & Hughes	Vestibular deficits in deaf children	1996	An et al, 2009
Suarez, Angeli, Suarez, Rosales, Carrera, & Alonso	Balance sensory organization in children with profound hearing loss and cochlear implants	2004	An et al, 2009
Walicka-Cupryś, Przygoda, Czenczek, Truszczyńska, Drzał-Grabiec, Zbigniew, & Tarnowski	Balance assessment in hearing-impaired children	2014	PubMed

VISUAL			
Author	**Title**	**Year**	**Found**
Bottari D., Nava E., Ley P., Pavani F.	Enhanced reactivity to visual stimuli in deaf individuals	2010	PubMed
Dye M.W.G., Bavelier D.	Attentional enhancements and deficits in deaf populations: An integrative review	2010	PubMed
Buckley D., Codina C., Bhardwaj P., Pascalis O.	Action video game players and deaf observers have larger Goldmann visual fields	2010	PubMed
Bottari D., Caclin A., Giard M.-H., Pavani F.	Changes in early cortical visual processing predict enhanced reactivity in deaf individuals	2011	PubMed
Bosworth R.G., Petrich J.A.F., Dobkins K.R.	Effects of attention and laterality on motion and orientation discrimination in deaf signers	2013	PubMed
Hauthal N., Sandmann P., Debener S., Thome J.D.	Visual movement perception in deaf and hearing individuals	2013	PubMed
Veena C.N., Nandan T.M., Vastrad B.C.	Visual reaction time in congenitally deaf children	2015	PubMed

Author	Title	Year	Found
Alencar, Butler, & Lomber	What and how the deaf brain sees	2018	PubMed
Bavelier, Dye, & Hauser	Do deaf individuals see better?	2006	Alencar et al, 2018
Bosworth, Petrich, & Dobkins	Effects of attention and laterality on motion and orientation discrimination in deaf signers	2013	PubMed
Bottari, Caclin, Giard, & Pavani	Changes in early cortical visual processing predict enhanced reactivity in deaf individuals	2011	PubMed
Bottari, Heimler, Caclin, Dalmolin, Giard, & Pavani	Visual change detection recruits auditory cortices in early deafness	2014	Cochrane
Bottari, Nava, Ley, & Pavani	Enhanced reactivity to visual stimuli in deaf individuals	2010	PubMed
Bottarri, Valsecchi, & Pavani	Prominent reflexive eye-movement orienting associated with deafness	2012	PubMed
Bross & Sauerwein,	Signal detection of visual flicker in deaf and hearing individuals	1980	Alencar et al, 2018
Brozinsky & Bavelier	Motion velocity thresholds in deaf signers: Changes in lateralization but not in overall sensitivity	2004	Alencar et al, 2018
Buckley, Codina, Bhardwaj, & Pascalis	Action video game players and deaf observers have larger Goldmann visual fields	2010	PubMed
Cattaneo, Cecchetto, & Papagno	Deaf Individuals Show a Leftward Bias in Numerical Bisection	2016	PubMed
Cattaneo, Rinaldi, Geraci, Cecchetto, & Papagno	Spatial biases in deaf, blind, and deafblind individuals as revealed by a haptic line bisection task	2018	PubMed
Codina, Buckley, Port, & Pascalis,	Deaf and hearing children: A comparison of peripheral vision development	2011	Alencar et al, 2018
Codina, Pascalis, Mody, Toomey, Rose, Gummer, & Buckley	Visual advantage in deaf adults linked to retinal changes	2011	PubMed
Dye & Bavelier	Attentional enhancements and deficits in deaf populations: An integrative review	2010	PubMed
Gori, Chilosi, Forli, & Burr	Audio-visual temporal perception in children with restored hearing	2017	PubMed
Güdücü, Ergönül, Öniz, İkiz, & Özgören	Deaf adolescents have bigger responses for somatosensory and visual stimulations	2019	PubMed
Hauthal, Sandmann, Debener, & Thome	Visual movement perception in deaf and hearing individuals	2013	PubMed

Author	**Title**	**Year**	**Found**
Hollingsworth, Ludlow, Wilkins, Calver, & Allen	Visual performance and ocular abnormalities in deaf children and young adults: A literature review	2014	Alencar et al, 2018
Iversen, Patel, Nicodemus, & Emmorey	Synchronization to auditory and visual rhythms in hearing and deaf individuals	2015	Alencar et al, 2018
Megreya & Bindemann	A visual processing advantage for young-adolescent deaf observers: Evidence from face and object matching tasks	2017	Alencar et al, 2018
Parasnis, Samar, Bettger, & Sathe	Does deafness lead to enhancement of visual spatial cognition in children? Negative evidence from deaf nonsigners	1996	Alencar et al, 2018
Samar & Berger	Does a flatter general gradient of visual attention explain peripheral advantages and central deficits in deaf adults?	2017	PubMed
Scott, Karns, Dow, Stevens, & Neville	Enhanced peripheral visual processing in congenitally deaf humans is supported by multiple brain regions, including primary auditory cortex	2014	PubMed
Seymour, Low, Maclin, Chiarelli, Mathewson, Fabiani, Gratton, & Dye	Reorganization of neural systems mediating peripheral visual selective attention in the deaf: An optical imaging study	2017	PubMed
Shiell & Zatorre	White matter structure in the right planum temporale region correlates with visual motion detection thresholds in deaf people	2017	PubMed
Shiell, Champoux, & Zatorre	Enhancement of visual motion detection thresholds in early deaf people	2014	Cochrane
Shiell, Champoux, & Zatorre	The Right Hemisphere Planum Temporale Supports Enhanced Visual Motion Detection Ability in Deaf People: Evidence from Cortical Thickness	2016	PubMed
Vachon, Voss, Lassonde, Leroux, Mensour, Beaudoin, Bourgouin, & Lepore	Reorganization of the auditory, visual and multimodal areas in early deaf individuals	2013	Cochrane
Veena, Nandan, & Vastrad	Visual reaction time in congenitally deaf children	2015	PubMed
Yukhymenko	Cortical Visual Evoked Potentials in Subjects with Auditory Deprivation (Congenital Deafness)	2017	PubMed

SENSORY PROCESSING DYSFUNCTION			
Author	**Title**	**Year**	**Found**
Bharadwaj, S. Daniel, L.L. & Matzke, P.L	Sensory-Processing Disorder in Children With Cochlear Implants	2009	PubMed
Crowe, T.K & Horak, F.B.	Motor Proficiency Associated with Vestibular Deficits in Children with Hearing Impairments	1988	Bharadwaj et al, 2009
Rhoades, E. A., & Chisolm, T. H.	Global language progress with an auditory–verbal approach for children who are deaf or hard of hearing	2001	Bharadwaj et al, 2009

Appendix 3 – Ethical Approval from University of Hertfordshire's Health, Science, Engineering and Technology Ethics Committee with Delegated Authority.

Ethical Approval for Study

University of Hertfordshire UH

HEALTH SCIENCE ENGINEERING & TECHNOLOGY ECDA

ETHICS APPROVAL NOTIFICATION

TO	Kimberley Coulson
CC	Keith Sullivan
FROM	Dr Simon Trainis, Health, Science, Engineering & Technology ECDA Chair.
DATE	05/07/2019

Protocol number: **LMS/PGT/UH/03814**

Title of study: Exploring Sensory Processing Profiles among Deaf People: Implications for Mental Wellbeing

Your application for ethics approval has been accepted and approved by the ECDA for your School and includes work undertaken for this study by the named additional workers below:

This approval is valid:

From: 05/07/2019

To: 01/07/2020

Additional workers: **Dr Keith Sullivan**
Dr Amanda Ludlow

Please note:

If your research involves invasive procedures you are required to complete and submit an EC7 Protocol Monitoring Form, and your completed consent paperwork to this ECDA once your study is complete. You are also required to complete and submit an EC7 Protocol Monitoring Form if you are a member of staff. This form is available via the Ethics Approval StudyNet Site via the 'Application Forms' page http://www.studynet1.herts.ac.uk/ptl/common/ethics.nsf/Teaching+Documents?Openview&count=9999&restricttocategory=Application+Forms

Any necessary permissions for the use of premises/location and accessing participants for your study must be obtained in writing prior to any data collection commencing. Failure to obtain adequate permissions may be considered a breach of this protocol.

Approval applies specifically to the research study/methodology and timings as detailed in your Form EC1A. Should you amend any aspect of your research, or wish to apply for an extension to your study, you will need your supervisor's approval (if you are a student) and must complete and submit form EC2. In cases where the amendments to the original study are deemed to be substantial, a new Form EC1A may need to be completed prior to the study being undertaken.

Should adverse circumstances arise during this study such as physical reaction/harm, mental/emotional harm, intrusion of privacy or breach of confidentiality this must be reported to the approving Committee immediately. Failure to report adverse circumstance/s would be considered misconduct.

Ensure you quote the UH protocol number and the name of the approving Committee on all paperwork, including recruitment advertisements/online requests, for this study.

Students must include this Approval Notification with their submission.

Ethical Approval for Change of Study Name

University of Hertfordshire UH

HEALTH, SCIENCE, ENGINEERING AND TECHNOLOGY ECDA

ETHICS APPROVAL NOTIFICATION

TO	Kim Coulson Thacker
CC	Dr Amanda Ludlow and Dr Keith Sullivan
FROM	Dr Simon Trainis, Health, Science, Engineering & Technology ECDA Chair.
DATE	24/10/2019

Protocol number: **aLMS/PGT/UH/03814(1)**

Title of study: Exploring Sensory Processing Profiles among Deaf People: Implications for Mental Wellbeing"

Your application to modify and extend the existing protocol as detailed below has been accepted and approved by the ECDA for your School and includes work undertaken for this study by the named additional workers below:

Dr Amanda Ludlow and Dr Keith Sullivan

Modification: Study title amendment.

General conditions of approval:

Ethics approval has been granted subject to the standard conditions below:

Original protocol: Any conditions relating to the original protocol approval remain and must be complied with.

Permissions: Any necessary permissions for the use of premises/location and accessing participants for your study must be obtained in writing prior to any data collection commencing. Failure to obtain adequate permissions may be considered a breach of this protocol.

External communications: Ensure you quote the UH protocol number and the name of the approving Committee on all paperwork, including recruitment advertisements/online requests, for this study.

Invasive procedures: If your research involves invasive procedures you are required to complete and submit an EC7 Protocol Monitoring Form, and copies of your completed consent paperwork to this ECDA once your study is complete.

Submission: Students must include this Approval Notification with their submission.

Validity:

This approval is valid:

From: 24/10/2019

To: 01/07/2020

Please note:

Failure to comply with the conditions of approval will be considered a breach of protocol and may result in disciplinary action which could include academic penalties.
Additional documentation requested as a condition of this approval protocol may be submitted via your supervisor to the Ethics Clerks as it becomes available. All documentation relating to this study, including the information/documents noted in the conditions above, must be available for your supervisor at the time of submitting your work so that they are able to confirm that you have complied with this protocol.

Should you amend any aspect of your research or wish to apply for an extension to your study you will need your supervisor's approval (if you are a student) and must complete and submit a further EC2 request.
Approval applies specifically to the research study/methodology and timings as detailed in your Form EC1A or as detailed in the EC2 request. In cases where the amendments to the original study are deemed to be substantial, a new Form EC1A may need to be completed prior to the study being undertaken.

Failure to report adverse circumstance/s may be considered misconduct.
Should adverse circumstances arise during this study such as physical reaction/harm, mental/emotional harm, intrusion of privacy or breach of confidentiality this must be reported to the approving Committee immediately.

Appendix 4 –Information Sheet and Consent Form

Information Sheet (presented to participants as part of an online survey)

You are being invited to take part in a research study based at the University of Hertfordshire. Before you decide whether to take part it is important you understand the study and what your involvement will include. Please read the following information carefully and discuss it with others if you wish. If anything is not clear, or if you would like further information before making a decision, please email me at k.coulson@herts.ac.uk or Tweet me @KCoulsonThaker.

Who has approved this study? The University of Hertfordshire's Health, Science, Engineering and Technology Ethics Committee with Delegated Authority. The UH protocol number is LMS/PGT/UH/03814. Regulations governing the conduct of studies involving human participants can be accessed here.

What is the purpose of this study? This study aims to explore relationships between sensory processing and mental wellbeing in hearing and d/Deaf children between 5 and 10 years of age. This will be done via parents/guardians answering some online questionnaires about their children's sensory processing and wellbeing.

Do I have to take part? It is completely up to you whether or not you decide to take part in this study. If you do decide to take part, you will be asked to fill in an online consent form.

What if I take part then change my mind? Agreeing to join the study does not mean you have to complete all the questionnaires. If you choose to withdraw all the information collected from you will be deleted. If you do finish the questionnaires but later change your mind about being involved, **<u>you are free to withdraw from this study without giving a reason up to 31st March 2020.</u>** It may not be possible to withdraw your data after this time because I will have started to analyse the information collected. To withdraw your data please email me at k.coulson@herts.ac.uk with the unique ID number you will generate at the start of the survey

Who can take part in this study? Parents and caregivers of a d/Deaf or hearing child between 5 -10 years old.

How long will the study take? The online questionnaires take 20-30 minutes to complete on a computer. This can be done from your own home or anywhere else you feel comfortable.

What will happen to me if I take part? You will be shown a consent form to read. You will have to confirm you have read this. Once this has been completed, you will see more information about the aims of the research. You will then be asked if you still want to take part. You will be reminded that you do not have to answer any questions you do not want to and that you can choose not to finish the questionnaires.

You will then be asked to generate a unique ID number. It is important to make sure this is something you will remember in the future and to write it down. ***You will need this ID number if you decide to withdraw from the study after you have finished the questionnaires.***

You will be asked some questions about your child and their environment, (e.g. which language you use at home, your child's age, and hearing levels), their sensory processing, and their mental wellbeing. Once all the questions have been answered you will see a debrief form and be thanked for your participation.

I am concerned about my mental health or my child's. Where can I access support? I will only analyse the data from this study at a group level. This means I will not be looking at any individual people's answers to the questionnaires. This means I will not be able to give any information about a child's mental wellbeing or their sensory processing.

If you are concerned about your mental wellbeing, or that of your child, please contact your GP. Alternatively adults may self-refer to local their NHS psychological services. To find your local adult service please click here.

If you or your child are d/Deaf the following national resources may also be useful:
SignHealth (for adults)
Deaf4Deaf (for adults)
NDCS (for children and young people)

What are the possible disadvantages, risks or side effects of taking part? There are no known disadvantages, risks or side effects of participation in this study.

What are the possible benefits of taking part? This research aims to develop understanding of sensory processing, and how it might link to mental wellbeing. It is hoped the information gathered in this study can contribute towards understanding how to support people who experience difficulties with sensory processing.

How will my data be kept confidential? All data collected will be anonymised. Data will only be analysed and reported on at a group level. It will therefore not be possible to comment on individual's responses. Data will be securely stored on one secure, password-protected external hard drive. Only the research team will have access to this information.

What will happen to the data from this study? Information gathered in the study will be analysed. This will be used as part of the Principle Investigator's Doctoral thesis. It will also be written up for publication in scientific journals and may be presented at conferences. Your personal details will not be included in any publications. Only the Principle Investigator and their research team will have access to the data. Data will be kept for 5 years, as per the British Psychological Guidelines, after which time it will be destroyed under secure conditions.

Will the data be used in further studies? The data gathered in this study may be used for future research by the research team. Data will not be allowed to be used by different researchers. Data will remain in the possession of the principal investigator, accessible only by them and their research team. Your personal details will not be included in any publications.

Risk. If, during the study, any medical conditions or non-medical circumstances such as unlawful activity become apparent that might, or have, put others at risk, the University may refer the matter to the appropriate authorities.

Who can I contact if I have any questions? If you would like further information or would like to discuss any details of this study, please get in touch with me by email (k.coulson@herts.ac.uk).

Although we hope it is not the case, if you have any complaints or concerns about the way you have been approached or treated during this study, please write to the University's Secretary and Registrar at the following address:
Secretary and Registrar
University of Hertfordshire
College Lane
Hatfield
Herts
AL10 9AB

Thank you very much for reading this information and giving consideration to taking part in this study.

Consent Form (presented to participants as part of an online survey)

I freely agree to take part in the study "Exploring Children's Sensory Processing: Implications for Mental Wellbeing" (UH Protocol number: LMS/PGT/UH/03814)

I have been made aware of:
- The study's aims
- The methods and design of the study
- The names and contact details of key people
- The risks and potential benefits of taking part
- How the information collected will be stored and for how long
- Any plans for future studies that might involve further approaches to participants
- How my personal information will be stored and for how long
- What my involvement in the study will be

I have been assured I may withdraw my data from the study until 31st March 2020 without having to give a reason.

I know I can do this by emailing the Principle Investigator at K.Coulson@herts.ac.uk with the unique ID number I will create before I start the questionnaires.

I have been told:
- How information about me (data obtained in the course of the study, and data provided by me) will be used
- How it will be kept safe
- Who will have access to it
- How it may be used.

I agree ☐

Appendix 5 – Recruitment Information

Do you have a hearing, d/Deaf, or hearing impaired child between 5 & 10 years old?

Could you help improve our understanding of sensory processing and mental wellbeing among children?

Some children's mental wellbeing can be negatively impacted by the way they process sensory information. This can continue to impact them as teenagers and adults. This must be better understood in order to ensure recognition and support for children and their families.

Can you help by completing a 20 minute survey?

The survey can be done on a computer, tablet, or phone and accessed with:

- This link: Exploring Children's Sensory Processing and Mental Wellbeing
- This URL: https://herts.eu.qualtrics.com/jfe/form/SV_cvyd7hoAmjelQYB
- Or this QR Code

If you would like further information or would like to discuss any details of this study, please get in touch with me by email at k.coulson@herts.ac.uk.

This study has been reviewed by the University of Hertfordshire's Health, Science, Engineering and Technology Ethics Committee with Delegated Authority. The protocol number is LMS/PGT/UH/03814.

Appendix 6 - Recruitment Sites

Organisation	Location
School	Bedfordshire
School	Bedfordshire
School	Bedfordshire
School	Bedfordshire
School	Bedfordshire
School	Bedfordshire
School	Bedfordshire
School	Berkshire
School	Cambridgeshire
School	Cheshire
School	Derbyshire
School	Derbyshire
School	Devon
School	Essex
School	Essex
School	Essex
School	Essex
School	Hampshire
School	Hampshire
School	Hertfordshire
School	Hertfordshire
School	Hertfordshire
School	Ireland
School	Kent
School	Kent
School	Kent
School	Lancashire
School	London
School	London
School	London
School	London
School	London
School	London

Organisation	Location
School	London
School	London
School	London
School	London
School	London
School	London
School	London
School	Merseyside
School	Middlesex
School	North West England
School	Scotland
School	Scotland
School	South West England
School	Suffolk
School	Surrey
School	Surrey
School	Wales
School	West Midlands
School	West Midlands
School	West Midlands
School	Yorkshire
School	Yorkshire
School	Yorkshire
School	Yorkshire
School	Yorkshire
School	Yorkshire
School	Yorkshire
School	Yorkshire
Institute of Higher Learning	Wales
Third Sector Organisation	London
Third Sector Organisation	Scotland
Third Sector Organisation	National
Third Sector Organisation	National
Professional Organisation	National
Word of Mouth / “Snowball” method	National

Appendix 7 - SDQ – Parent Report

Strengths and Difficulties Questionnaire

For each item, please mark the box for Not True, Somewhat True or Certainly True. It would help us if you answered all items as best you can even if you are not absolutely certain or the item seems daft! Please give your answers on the basis of the child's behaviour over the last six months or this school year.

Child's Name .... Male/Female

Date of Birth...

	Not True	Somewhat True	Certainly True
Considerate of other people's feelings	☐	☐	☐
Restless, overactive, cannot stay still for long	☐	☐	☐
Often complains of headaches, stomach-aches or sickness	☐	☐	☐
Shares readily with other children (treats, toys, pencils etc.)	☐	☐	☐
Often has temper tantrums or hot tempers	☐	☐	☐
Rather solitary, tends to play alone	☐	☐	☐
Generally obedient, usually does what adults request	☐	☐	☐
Many worries, often seems worried	☐	☐	☐
Helpful if someone is hurt, upset or feeling ill	☐	☐	☐
Constantly fidgeting or squirming	☐	☐	☐
Has at least one good friend	☐	☐	☐
Often fights with other children or bullies them	☐	☐	☐
Often unhappy, down-hearted or tearful	☐	☐	☐
Generally liked by other children	☐	☐	☐
Easily distracted, concentration wanders	☐	☐	☐
Nervous or clingy in new situations, easily loses confidence	☐	☐	☐
Kind to younger children	☐	☐	☐
Often lies or cheats	☐	☐	☐
Picked on or bullied by other children	☐	☐	☐
Often volunteers to help others (parents, teachers, other children)	☐	☐	☐
Thinks things out before acting	☐	☐	☐
Steals from home, school or elsewhere	☐	☐	☐
Gets on better with adults than with other children	☐	☐	☐
Many fears, easily scared	☐	☐	☐

Appendix 8 - Extract From SPCQ

Sensory Processing

Item			A. Auditory Processing	ALWAYS	FREQUENTLY	OCCASIONALLY	SELDOM	NEVER
	L	1	Responds negatively to unexpected or loud noises (for example, cries or hides at noise from vacuum cleaner, dog barking, hair dryer)					
	L	2	Holds hands over ears to protect ears from sound					
	L	3	Has trouble completing tasks when the radio is on					
	L	4	Is distracted or has trouble functioning if there is a lot of noise around					
	L	5	Can't work with background noise (for example, fan, refrigerator)					
	H	6	Appears to not hear what you say (for example, does not "tune-in" to what you say, appears to ignore you)					
	H	7	Doesn't respond when name is called but you know the child's hearing is OK					
	H	8	Enjoys strange noises/seeks to make noise for noise's sake					
			Section Raw Score Total					

Comments

Item			B. Visual Processing	ALWAYS	FREQUENTLY	OCCASIONALLY	SELDOM	NEVER
	L	9	Prefers to be in the dark					
	L	10	Expresses discomfort with or avoids bright lights (for example, hides from sunlight through window in car)					
	L	11	Happy to be in the dark					
	L	12	Becomes frustrated when trying to find objects in competing backgrounds (for example, a cluttered drawer)					
	L	13	Has difficulty putting puzzles together (as compared to same age children)					
	L	14	Is bothered by bright lights after others have adapted to the light					
	L	15	Covers eyes or squints to protect eyes from light					
	H	16	Looks carefully or intensely at objects/people (for example, stares)					
	H	17	Has a hard time finding objects in competing backgrounds (for example, shoes in a messy room, favorite toy in the "junk drawer")					
			Section Raw Score Total					

Comments

Appendix 9 – SPCQ Technical Report

Technical Report

SENSORY PROFILE

Winnie Dunn

Overview 1
Benefits and Features 1
Description of Item Categories 2
Scores Provided 2
Research 2
Reliabilitiy and Validity 3
Summary 4

Overview

The *Sensory Profile*™ provides a standard method for professionals to measure the sensory processing abilities of children 5 to 10 years old (separate cut scores for 3 and 4 year olds are provided in the manual) and to profile the effects of sensory processing on functional performance in the children's daily lives. The *Sensory Profile* is a judgment-based questionnaire designed to contribute to a comprehensive assessment of a child's sensory performance when combined with other evaluations, observations, and reports.

The *Sensory Profile* uses a sensory integrative and neuroscience frame of reference and supports a family-centered care philosophy by involving the caregivers in the data-gathering process. The caregiver who has daily contact with the child completes the questionnaire by reporting the frequency with which behaviors described in the profile items occur. The therapist then scores the responses, and the team serving the child follows up on any relationship between sensory processing and performance difficulties.

Benefits and Features

The *Sensory Profile*™ provides an evaluation tool for professionals to gather information about children's sensory processing abilities that support and/or interfere with functional performance. Important features of the *Sensory Profile* include:

- capturing salient information about a child's sensory processing;
- clearly linking sensory processing with the child's daily life performance;
- providing information for theory-based decision making; and
- including caregivers as critical members of the team.

The test applies for children with all types of disabilities and severity levels. It is easy to administer, score, and interpret.

The *Sensory Profile* provides both a measure of current performance and an indication of intervention directions. Because the *Sensory Profile* is organized into sections, test results suggest which sensory systems might be interfering with the child's performance of daily tasks. The information gained from the *Sensory Profile* provides status of current performance levels; and the section scores and the factor structure provide guideposts for planning interventions with the families and other caregivers.

Description of Item Categories

The *Sensory Profile* consists of 125 items grouped into three main sections.

Sensory Processing contains six item categories that reflect particular types of sensory processing as part of daily life.

- **Auditory Processing** items measure the child's responses to things heard.
- **Visual Processing** items measure the child's responses to things seen.
- **Vestibular Processing** measures the child's responses to movement.
- **Touch Processing** measures the child's responses to stimuli that touch the skin.
- **Multisensory Processing** measures the child's responses to activities that contain a combined sensory experience.
- **Oral Sensory Processing** measures the child's responses to touch and taste stimuli to the mouth.

Modulation contains five item categories that reflect various combinations of input for use in daily life.

- **Sensory Processing Related to Endurance/Tone** measures the child's ability to sustain performance.
- **Modulation Related to Body Position and Movement** measures the child's ability to move effectively.
- **Modulation of Movement Affecting Activity Level** measures the child's demonstration of activeness.
- **Modulation of Sensory Input Affecting Emotional Responses** measures the child's ability to use body senses to generate emotional responses.
- **Modulation of Visual Input Affecting Emotional Responses and Activity Level** measures the child's ability to use visual cues to establish contact with others.

Behavioral and Emotional Responses contains three item categories that reflect emotional and behavioral responses that might indicate a child's sensory processing abilities.

- **Emotional/Social Responses** items indicate the child's psychosocial coping strategies.
- **Behavioral Outcomes of Sensory Processing** items indicate the child's ability to meet performance demands.
- **Thresholds for Response** items indicate the child's level of modulation.

Items on the Caregiver Questionnaire unite to form nine meaningful groups or factors: Sensory Seeking, Emotionally Reactive, Low Endurance/Tone, Oral Sensory Sensitivity, Inattention/Distractibility, Poor Registration, Sensory Sensitivity, Sedentary, and Fine Motor/Perceptual. The factors identify items on the Caregiver Questionnaire that characterize children by their responsiveness to sensory input (i.e., overly responsive or underresponsive).

A short form of the *Sensory Profile* targets sensory modulation rather than the more multidimensional aspects of development. Researchers selected 38 items from the *Sensory Profile* that were the most indicative of sensory processing issues that affect performance. The *Short Sensory Profile* is most appropriate for screening programs and research protocols.

Scores Provided

Researchers defined a classification system, based on the performance of 1,057 children without disabilities, by determining cut scores for each section and factor raw score totals. The classification system describes the child's sensory processing abilities for each section and factor as Typical Performance, Probable Difference, or Definite Difference and helps the professional quickly determine whether a child's performance on any section or factor groupings is of concern.

Research

The research on the *Sensory Profile* took place from 1993 to 1999 and included more than 1,200 children with and without disabilities between the ages of 3 and 14.

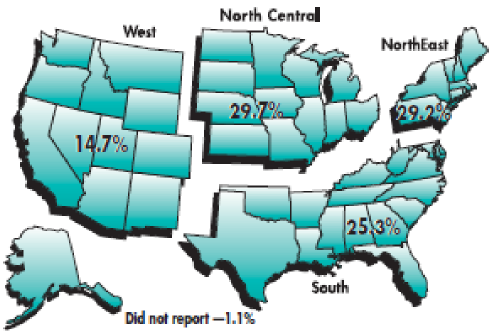
The 166 occupational therapists who participated as examiners provided a sample of 1,037 children without disabilities.

Examiners tested 524 girls and 510 boys, with gender for three children not reported. Children were excluded from the sample if caregivers reported they were receiving special education services and were on regular prescription medication.

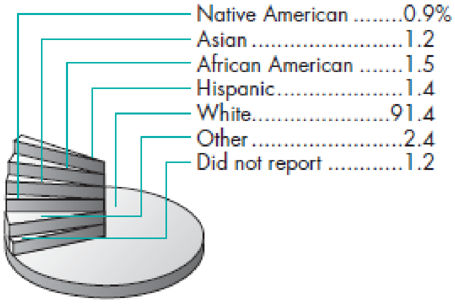
Age in years and months	3.0 to 3.11	4.0 to 4.11	5.0 to 5.11	6.0 to 6.11	7.0 to 7.11	8.0 to 8.11	9.0 to 9.11	10.0 to 10.11	Total
Sample* Number	139	138	140	124	139	127	110	120	1,037

*Children without disabilities

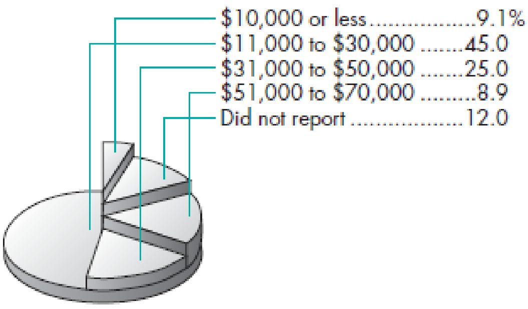
Sample by Geographic Region



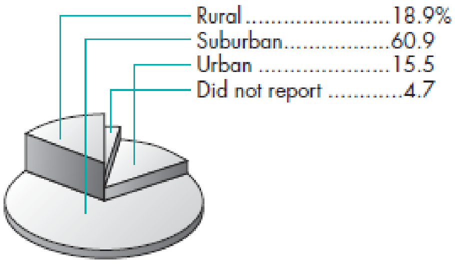
Race/Ethnicity Sample



Income Sample



Community Sample



Researchers also conducted studies with smaller samples of children with various disabilities to establish validity. Children in the studies had been identified previously as having attention deficit/hyperactivity disorder (61 between ages 3 and 15 years), autism/pervasive developmental disorder (32 between ages 3 and 13 years), Fragile X disorder (24 between ages 3 and 17 years), or a sensory modulation disorder (21 between ages 4 and 9 years). A small number of children with other behavior or learning disabilities also were included.

Reliability and Validity

Test reliability is an indication of the degree to which a test provides a precise and stable score. Cronbach's coefficient alpha was calculated to examine the internal consistency for each section of the *Sensory Profile*. Internal consistency indicates the extent to which the items in each section measure a single construct. The values of alpha for the various sections ranged from .47 to .91.

Content validity was established during development of the *Sensory Profile* by determining that the test sampled the full range of children's sensory processing behaviors and that the items were placed appropriately within sections. Methods used included a literature review, expert review by eight therapists experienced in applying sensory integration theory to practice, and category analysis based on a national study. The study included 155 occupational therapists who categorized the items in the *Sensory Profile* without cues about where the items would be placed. Results indicated that 80% of the therapists agreed on the category placement on 63% of the items. For the remaining items, new categories were developed.

To examine the convergent and discriminant validity of the *Sensory Profile*, various scores obtained on the *Sensory Profile* were compared with different functional tasks as measured by the *School Function Assessment*.

Researchers hypothesized that some school functions would be related to aspects of sensory processing while others would be independent of sensory processing. The *School Function Assessment* was selected because professionals and caregivers are interested in children's performance at school.

Researchers expected to see the following relationships, which would establish convergent validity:

- High correlations between the *School Function Assessment* performance items and the items in Factor 9 (Fine Motor/Perceptual) on the *Sensory Profile* because both measures evaluate product behaviors such as hand use.
- High correlations between the *School Function Assessment* socialization and behavior interaction sections and the modulation sections and factors on the *Sensory Profile* because children who have difficulty regulating sensory input have difficulty constructing appropriate responses.

Researchers expected to see the following relationships to establish discriminant validity:

- Low correlations between the *School Function Assessment* sections that capture daily routines and the sensory sections of the *Sensory Profile* because children can learn these routines as patterns of performance that do not require planning each time.

As expected, there were large and meaningful correlations between the *Sensory Profile's* Factor 9 (Fine Motor/Perceptual) and the performance items of the *School Function Assessment*. The moderate correlations between the Behavioral Regulation and Positive Interaction sections of the *School Function Assessment* and the modulation sections from the *Sensory Profile* also suggest convergent validity. The study findings also provide evidence of discriminant validity. Researchers found low correlations between the more detailed performance items on the *School Function Assessment* and the items on the *Sensory Profile*.

Clinical Group Studies

The performance of clinical groups with disabilities was compared to the research sample of children without disabilities to determine whether the *Sensory Profile* could delineate among the groups based on the children's responses to sensory events in daily life. The clinical groups included children with autism and those with ADHD.

Thirty-two children 3 to 13 years old who had autism were evaluated. On nearly 90% of the items, children with autism showed performance that was meaningfully different from the performance of children without disabilities. They engaged in the behaviors on the *Sensory Profile* more frequently than children without disabilities.

Further analysis showed the items that were most different scattered across all factors on the *Sensory Profile*.

Sixty-one children 3 to 15 years old who had ADHD were evaluated. They exhibited 113 of the 125 behaviors on the *Sensory Profile* more frequently than children without disabilities. From this study, a separate reproducible ADHD worksheet was developed. This worksheet (located in the manual) can be used as part of comprehensive assessment data for diagnosing ADHD and can be used to validate parents' and teachers' referral concerns.

Summary

The *Sensory Profile* provides a standard method to measure a child's sensory processing abilities and to profile the effect of sensory processing on functional performance in the daily life of the child. The *Sensory Profile* uses a sensory integrative and neuroscience frame of reference and supports a family-centered care philosophy by involving the caregivers in the data-gathering process. The test provides the necessary link between performance in daily life and theory in order to facilitate diagnosis and intervention planning.

Appendix 10 – One Sample T-Test Results

Item Scores: One Sample T-tests for Differences in Mean Sensory Profile Scores for d/Deaf and typically developing children, and children with a diagnosed with of ASD and ADHD

					95% CI	
	Group	**t**	**Sig. (2-tailed)**	**Mean Difference**	**Lower**	**Upper**
Auditory Processing	Typical	-10.12	<0.001	-8.16	25.31	26.41
	ASD	0.67	0.513	0.86	-1.83	3.54
	ADHD	1.60	0.125	2.06	-0.63	4.74
Visual Processing	Typical	-11.98	<0.001	-0.95	35.98	37.16
	ASD	4.33	<0.001	5.97	3.09	8.85
	ADHD	4.40	<0.001	6.07	3.19	8.95
Vestibular Processing	Typical	-18.96	<0.001	-5.55	45.45	46.84
	ASD	2.07	0.052	3.34	-0.03	6.72
	ADHD	2.13	0.046	3.44	0.07	6.82
Touch Processing	Typical	-27.18	<0.001	-3.43	76.25	78.13
	ASD	7.79	<0.001	17.09	12.51	21.67
	ADHD	5.37	<0.001	11.79	7.21	16.37
Multisensory Processing	Typical	-7.11	<0.001	-3.12	26.76	27.90
	ASD	4.99	<0.001	6.63	3.86	9.41
	ADHD	3.79	0.001	5.03	2.26	7.81
Oral Sensory Processing	Typical	-14.41	<0.001	-3.35	48.21	50.08
	ASD	5.01	<0.001	10.94	6.39	15.5
	ADHD	2.17	0.042	4.74	0.19	9.3
Sensory Processing Related to Endurance/Tone	Typical	-13.17	<0.001	-3.96	38.19	39.61
	ASD	2.71	0.013	4.5	1.04	7.97
	ADHD	1.21	0.241	2.00	-1.46	5.47
Modulation Related to Body Position and Movement	Typical	-18.66	<0.001	-2.94	42.10	43.23
	ASD	5.13	<0.001	6.77	4.02	9.52
	ADHD	4.60	<0.001	6.07	3.32	8.82
Modulation of Movement Affecting Activity Level	Typical	-6.88	<0.001	-2.52	24.55	25.35
	ASD	3.78	0.001	3.55	1.59	5.51
	ADHD	3.35	0.003	3.15	1.19	5.11
Modulation of Sensory Input Affecting Emotional Responses	Typical	3.43	0.003	-2.63	15.17	15.17
	ASD	4.61	<0.001	3.82	2.09	5.55
	ADHD	1.47	0.156	1.22	-0.51	2.95
Modulation of Visual Input Affecting Emotional Responses and Activity Level	Typical	6.15	<0.001	-1.18	15.73	16.27
	ASD	5.47	<0.001	3.40	2.1	4.7
	ADHD	5.47	<0.001	3.40	2.1	4.7
Emotional/Social Response	Typical	-15.09	<0.001	-7.93	62.05	64.91
	ASD	3.76	0.001	12.58	5.61	19.55
	ADHD	3.14	0.005	10.48	3.51	17.45
Behavioural Outcomes of Sensory Processing	Typical	-3.27	0.004	-2.94	21.94	23.11
	ASD	4.12	0.001	5.62	2.78	8.47
	ADHD	2.36	0.028	3.22	0.38	6.07
Items Indicating Thresholds for Response	Typical	13.48	<0.001	-1.04	12.24	12.71
	ASD	4.28	<0.001	2.38	1.22	3.53
	ADHD	4.46	<0.001	2.48	1.32	3.63

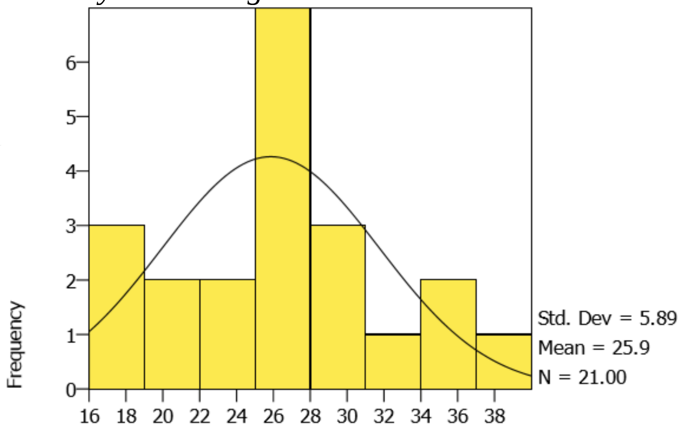
Factor Scores: One Sample T-tests for Differences in Mean Sensory Profile Scores for d/Deaf and typically developing children, and children with a diagnosed with of ASD and ADHD

	Group	t	Sig. (2-tailed)	Mean Difference	95% CI Lower	95% CI Upper
Factor 1: Sensory Seeking	Typical	-2.92	0.009	-8.29	-14.22	-2.36
	ASD	3.41	0.003	9.71	3.78	15.64
	ADHD	4.89	<0.001	13.91	7.98	19.84
Factor 2: Emotional Reactivity	Typical	-2.21	0.039	-7.77	-15.09	-0.45
	ASD	4.11	0.001	14.43	7.11	21.75
	ADHD	3.26	0.004	11.43	4.11	18.75
Factor 3: Low Endurance/Tone	Typical	-2.04	0.054	-3.40	-6.86	0.07
	ASD	2.71	0.013	4.50	1.04	7.97
	ADHD	1.21	0.241	2.00	-1.46	5.47
Factor 4: Oral Sensitivity	Typical	-1.48	0.154	-2.72	-6.56	1.11
	ASD	3.25	0.004	5.98	2.14	9.81
	ADHD	1.62	0.121	2.98	-0.86	6.81
Factor 5: Inattention/Distractability	Typical	-4.78	<0.001	-5.95	-8.54	-3.35
	ASD	1.65	0.114	2.05	-0.54	4.65
	ADHD	3.18	0.005	3.95	1.36	6.55
Factor 6: Poor Registration	Typical	-1.94	0.067	-1.65	-3.43	0.13
	ASD	8.86	<0.001	7.55	5.77	9.33
	ADHD	4.87	<0.001	4.15	2.37	5.93
Factor 7: Sensory Sensitivity	Typical	-1.76	0.093	-1.50	-3.26	0.27
	ASD	2.25	0.036	1.90	0.14	3.67
	ADHD	0.36	0.723	0.30	-1.46	2.07
Factor 8: Sedentary	Typical	-1.26	0.221	-1.19	-3.16	0.78
	ASD	0.96	0.346	0.91	-1.06	2.88
	ADHD	0.12	0.909	0.11	-1.86	2.08
Factor 9: Fine Motor/ Perceptual	Typical	-1.69	0.107	-1.26	-2.81	0.30
	ASD	6.78	<0.001	5.04	3.49	6.60
	ADHD	3.42	0.003	2.54	0.99	4.10

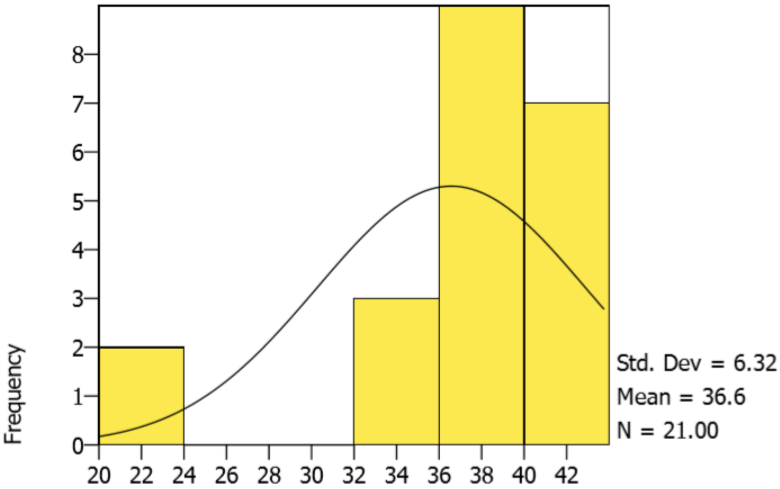
Appendix 11 – Histograms

Items Analysis: Sensory Profile Caregiver Questionnaire

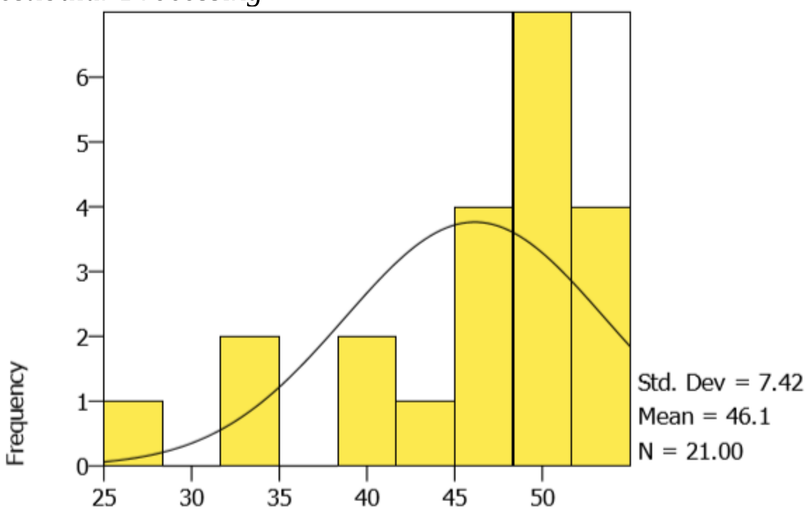
Auditory Processing



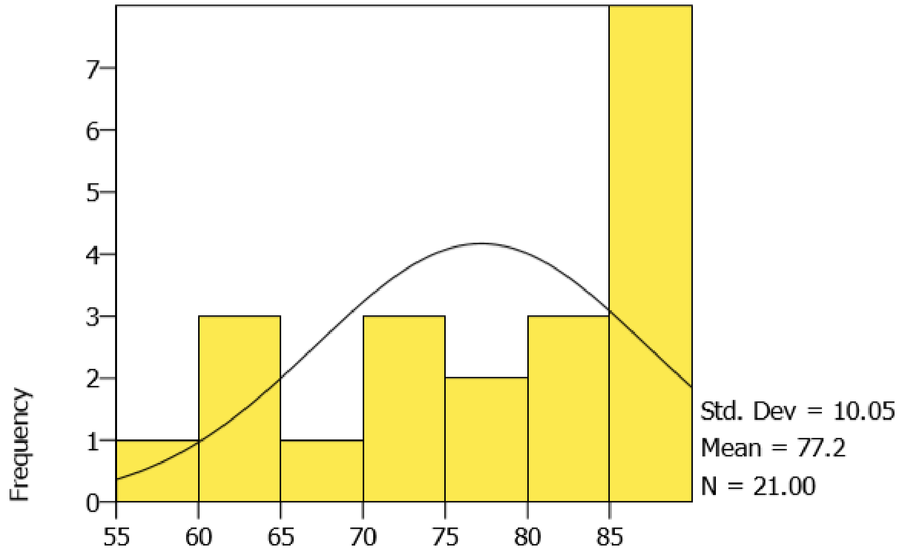
Visual Processing



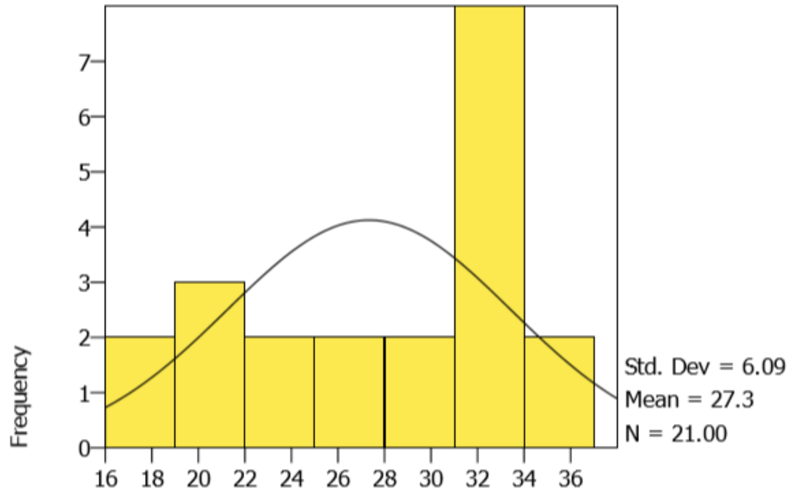
Vestibular Processing



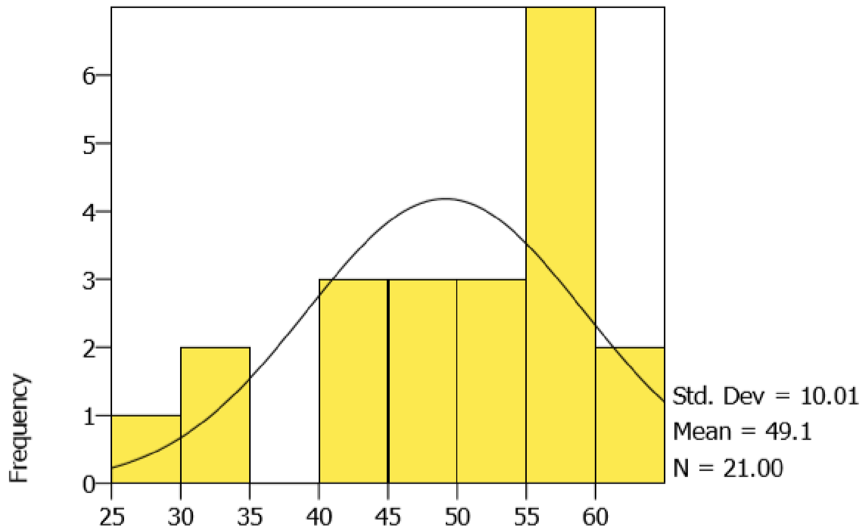
Touch Processing



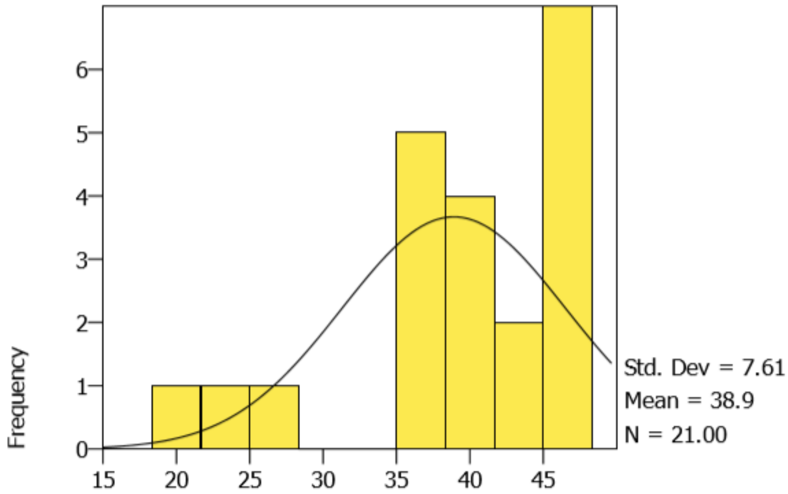
Multisensory Processing



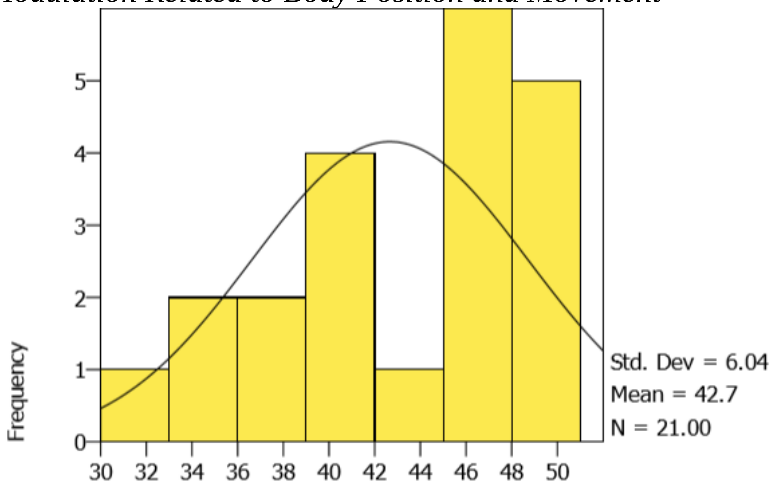
Oral Sensory Processing



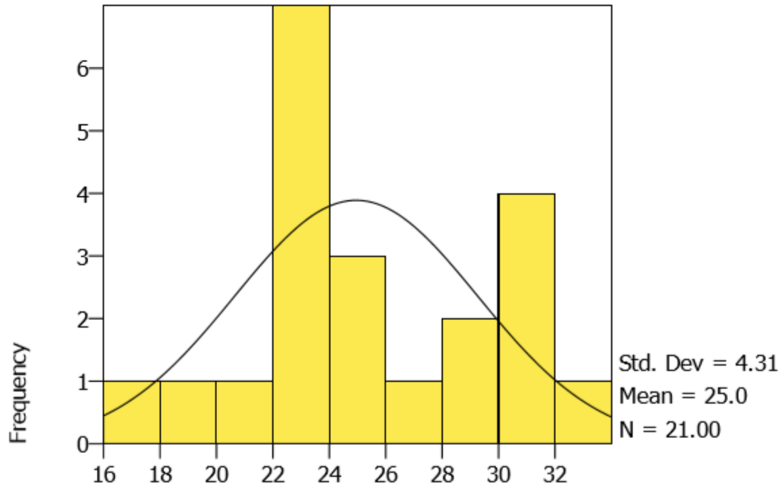
Sensory Processing Related to Endurance/Tone



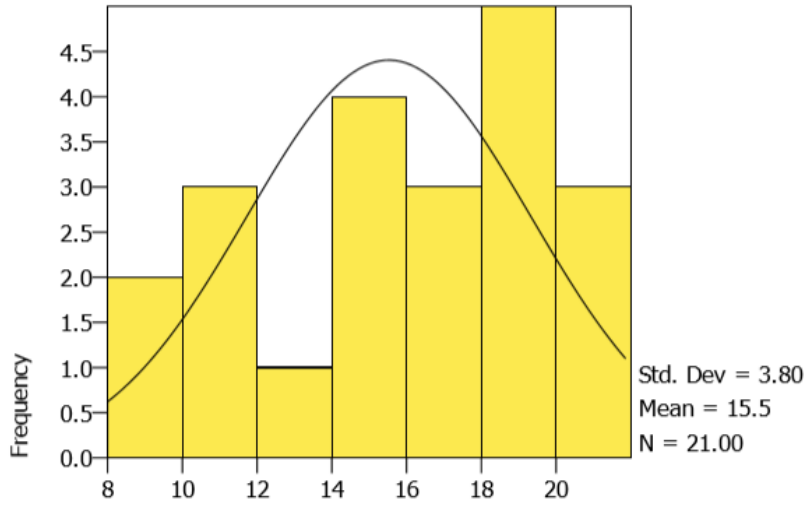
Modulation Related to Body Position and Movement



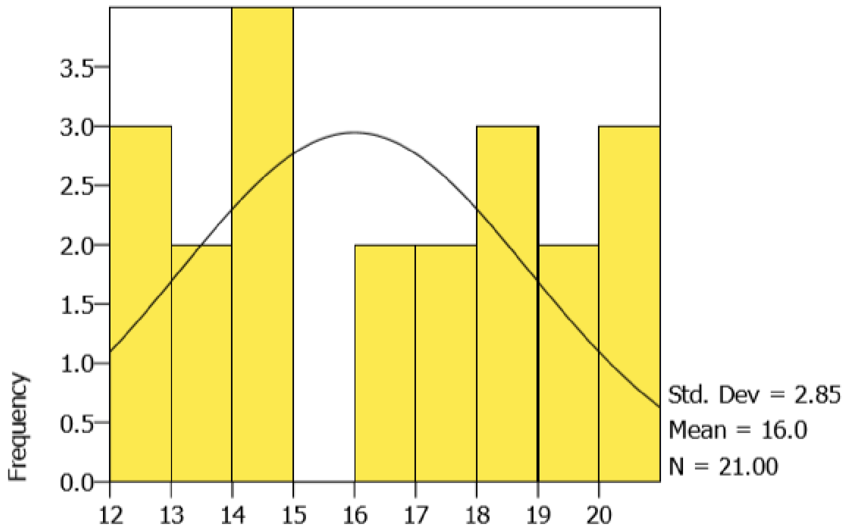
Modulation of Movement Affecting Activity Level



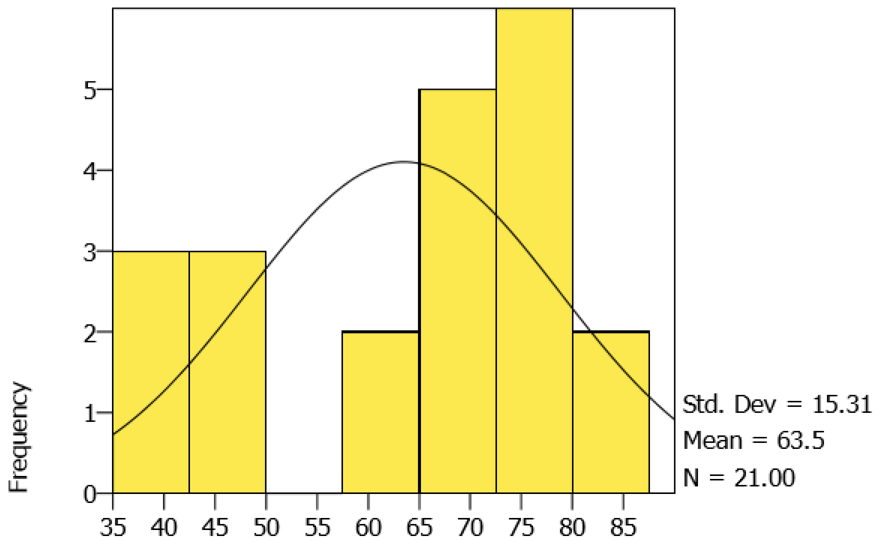
Modulation of Sensory Input Affecting Emotional Responses



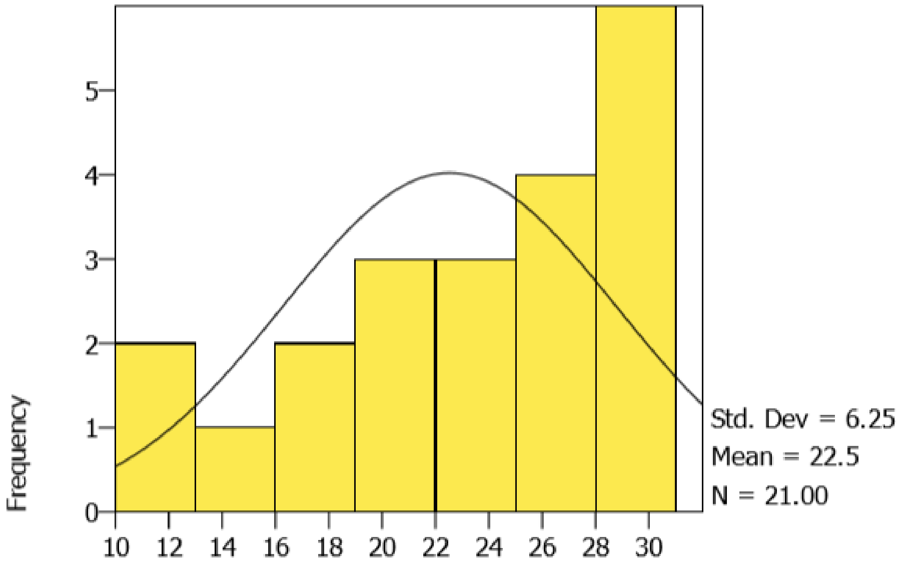
Modulation of Visual Input Affecting Emotional Responses and Activity Level



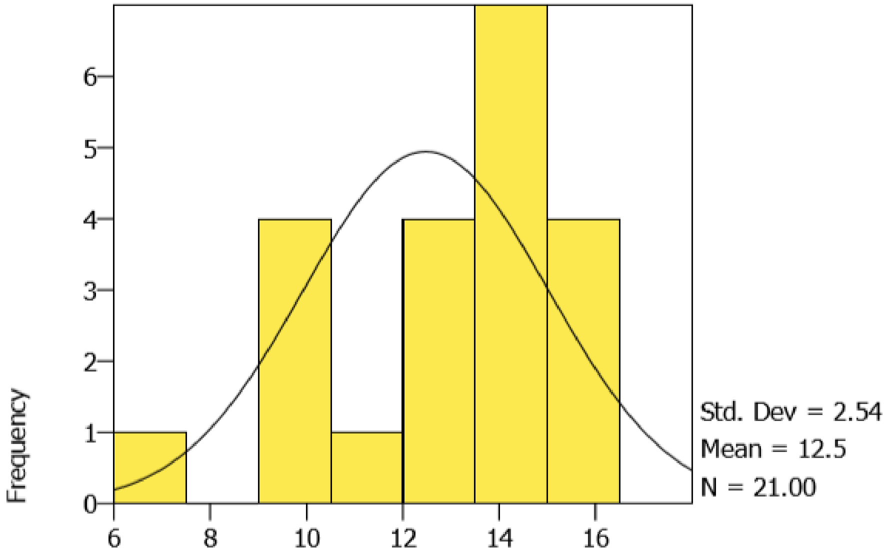
Emotional/Social Response



Behavioural Outcomes of Sensory Processing

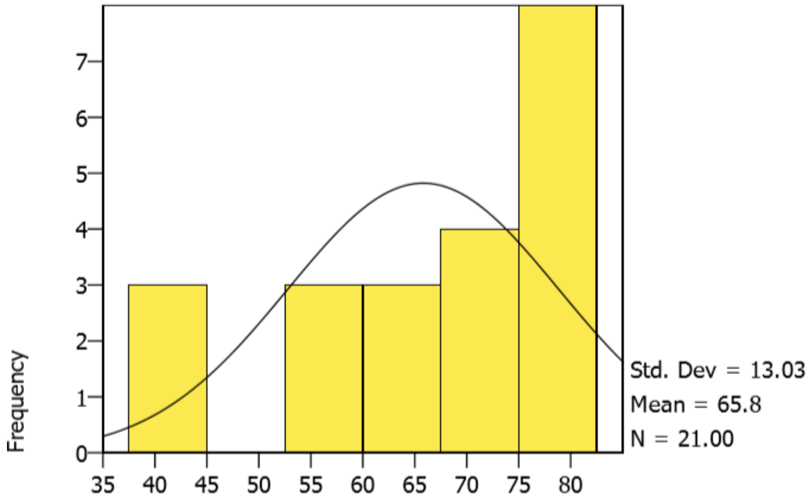


Items Indicating Thresholds for Response

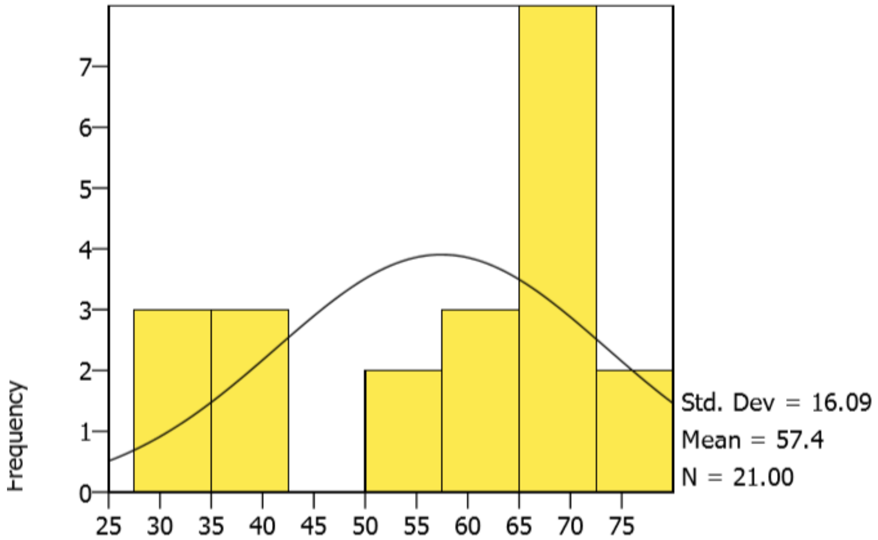


Factor Analysis: Sensory Profile Caregiver Questionnaire

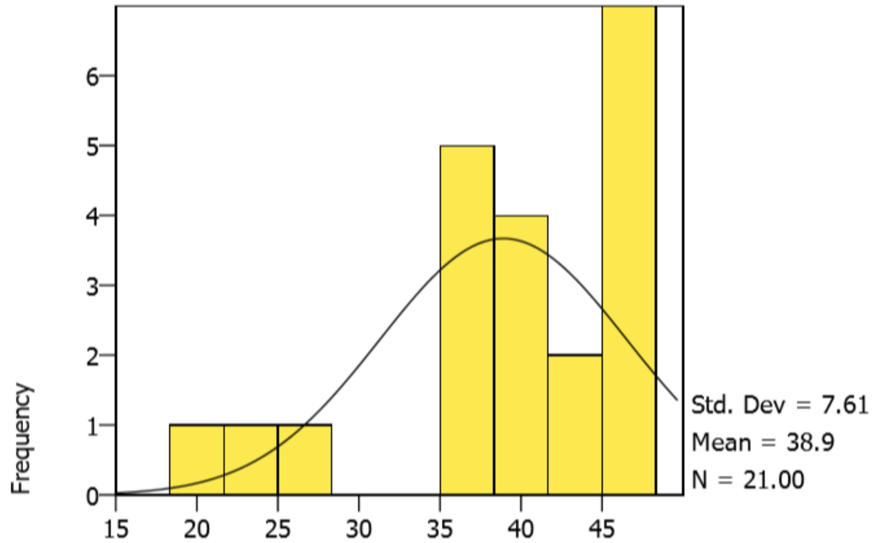
Factor 1: Sensory Seeking



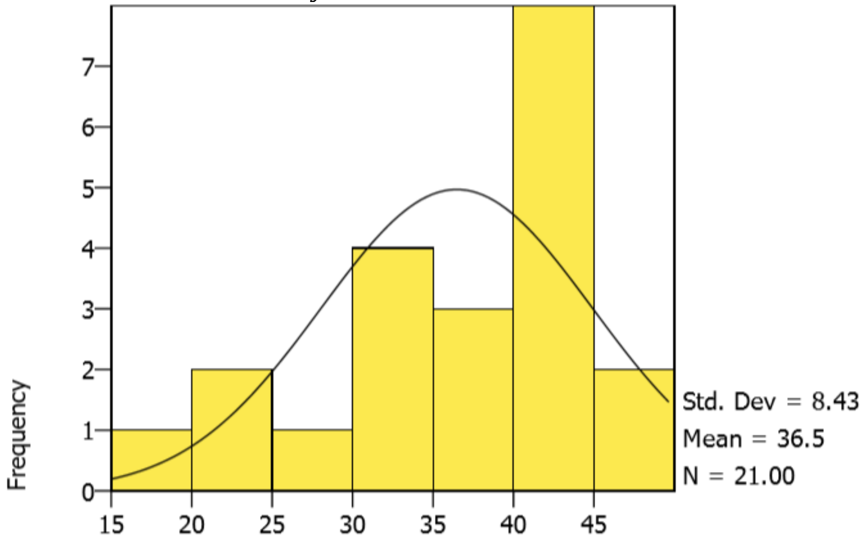
Factor 2: Emotional Reactivity



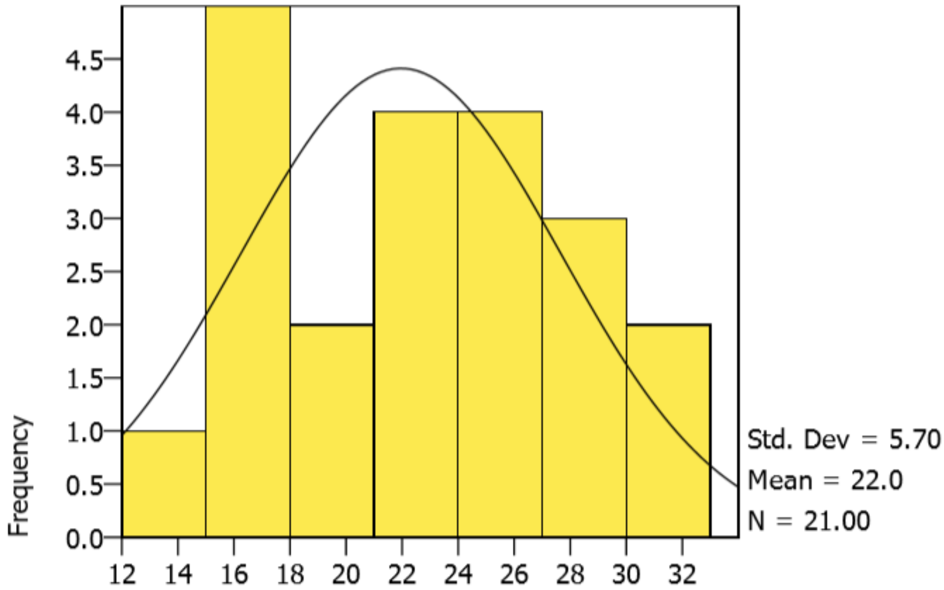
Factor 3: Low Endurance/Tone



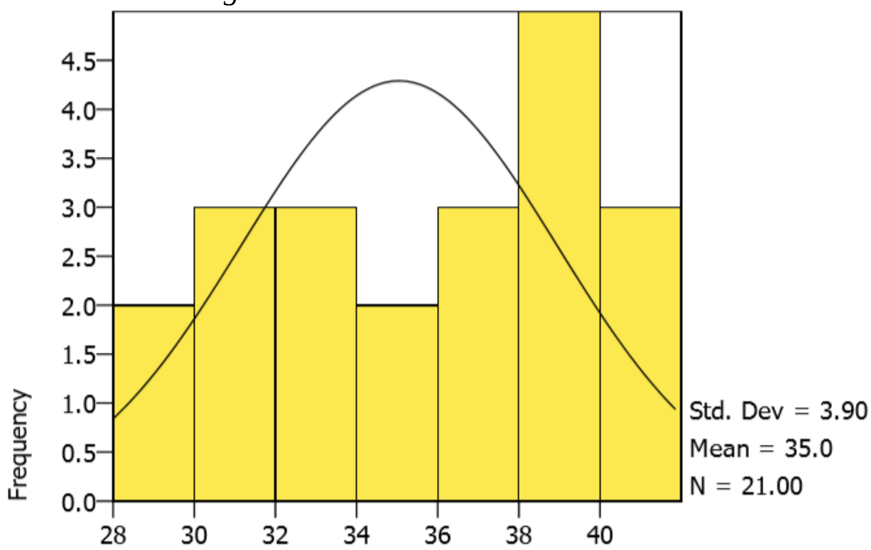
Factor 4: Oral Sensitivity



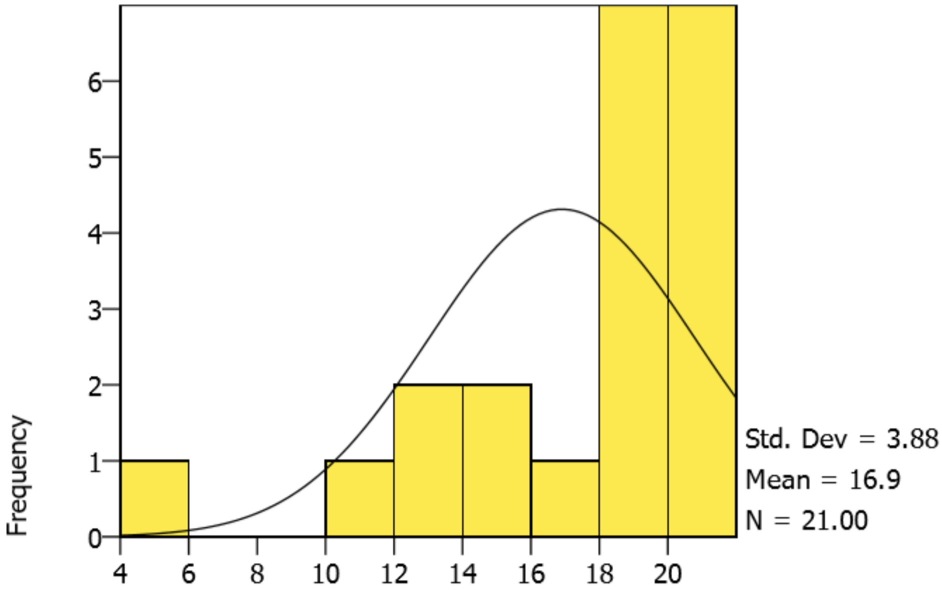
Factor 5: Inattention/Distractibility



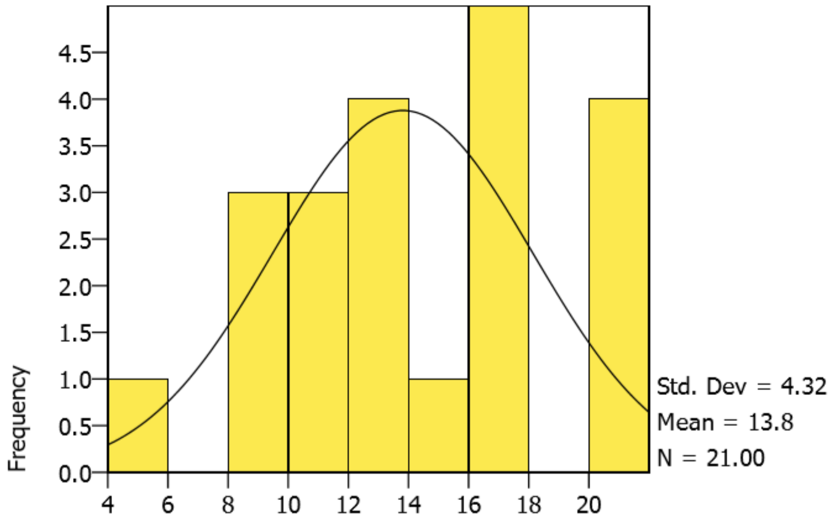
Factor 6: Poor Registration



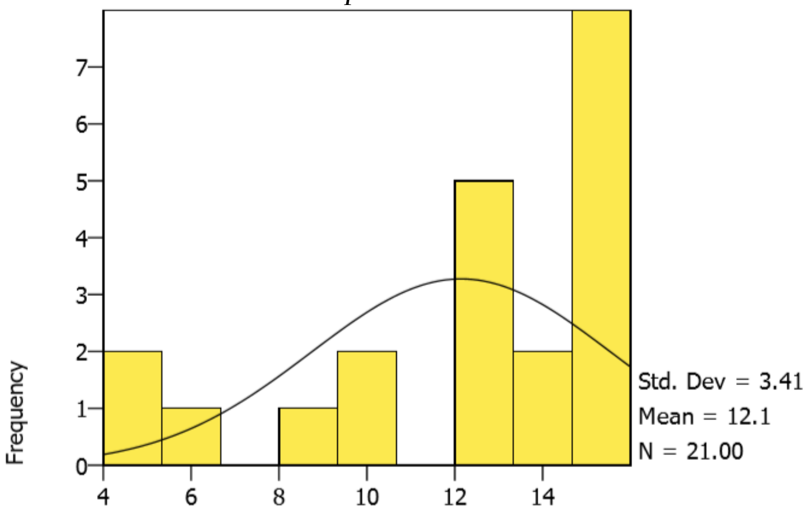
Factor 7: Sensory Sensitivity



Factor 8: Sedentary

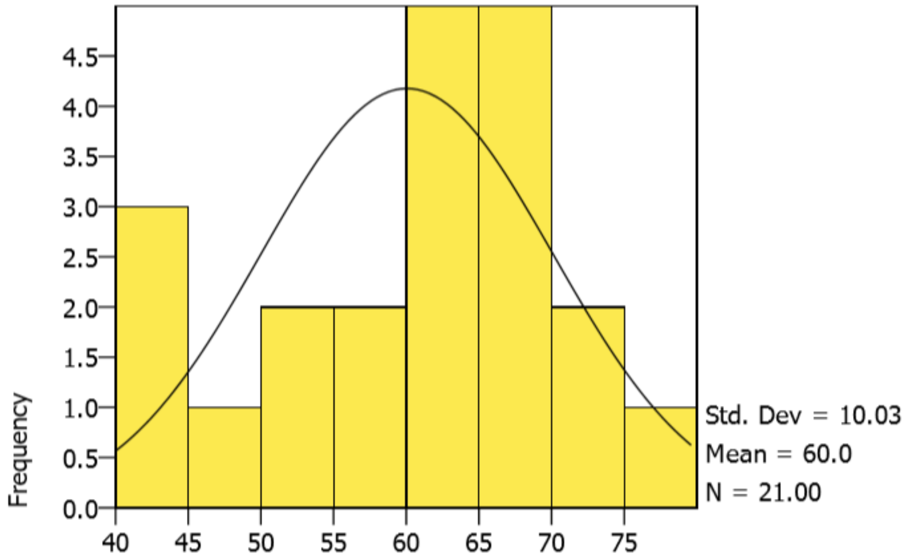


Factor 9: Fine Motor/Perceptual

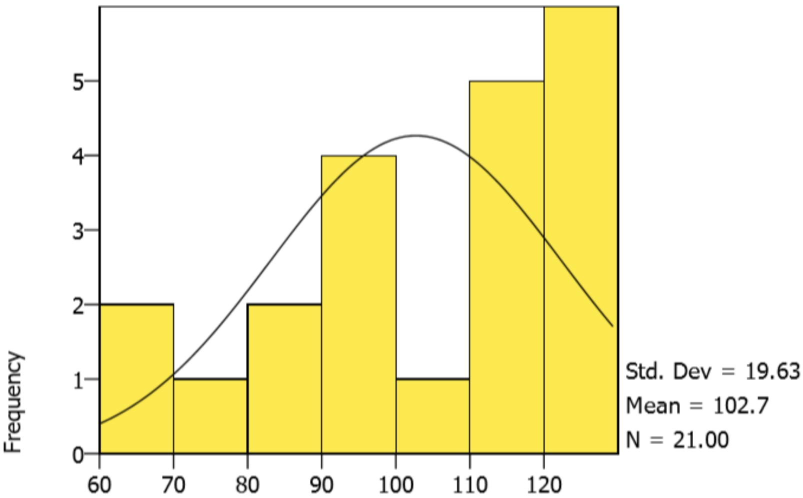


Quadrant Analysis: Sensory Profile Caregiver Questionnaire

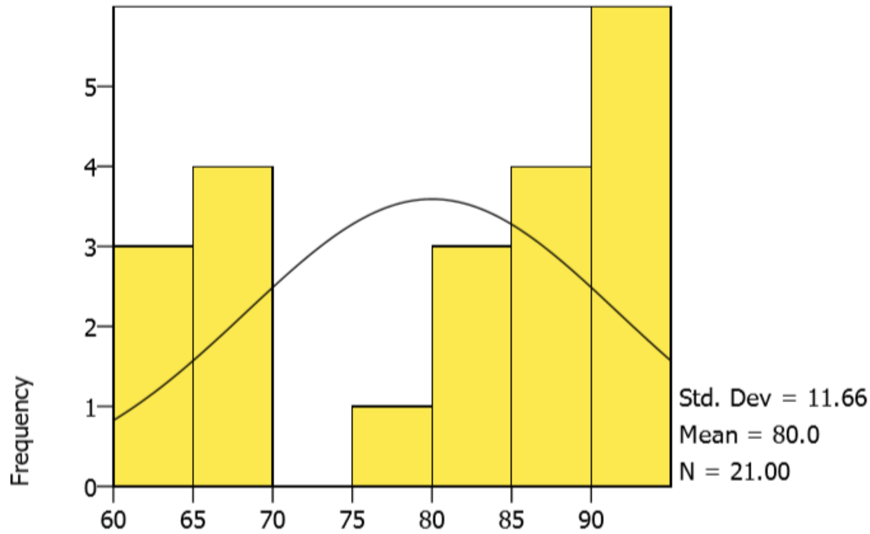
Quadrant 1: Low Registration



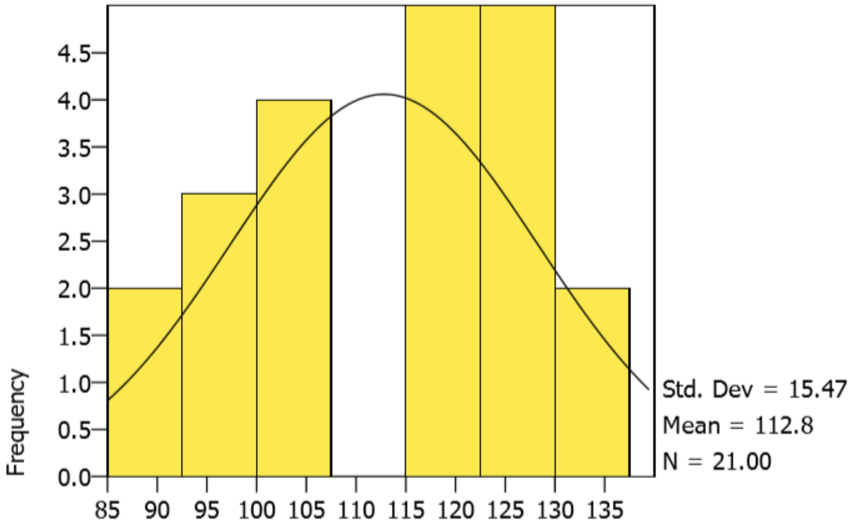
Quadrant 2: Sensation Seeking



Quadrant 3: Sensory Sensitivity

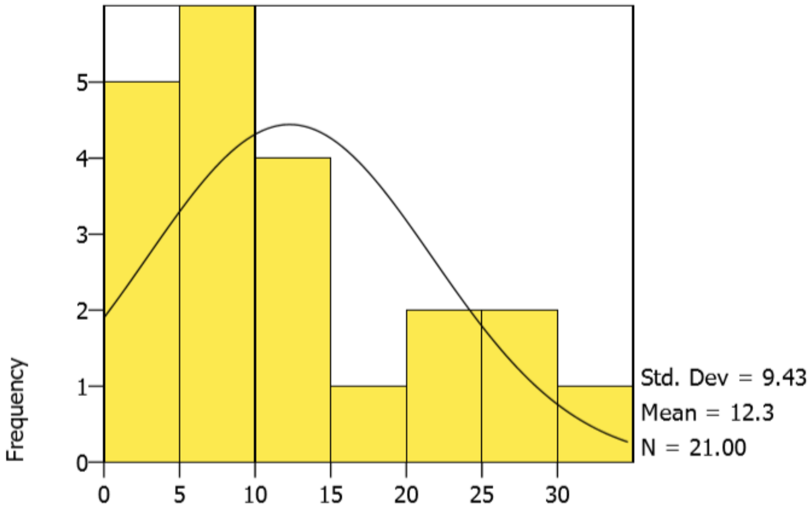


Quadrant 4: Sensation Avoidant

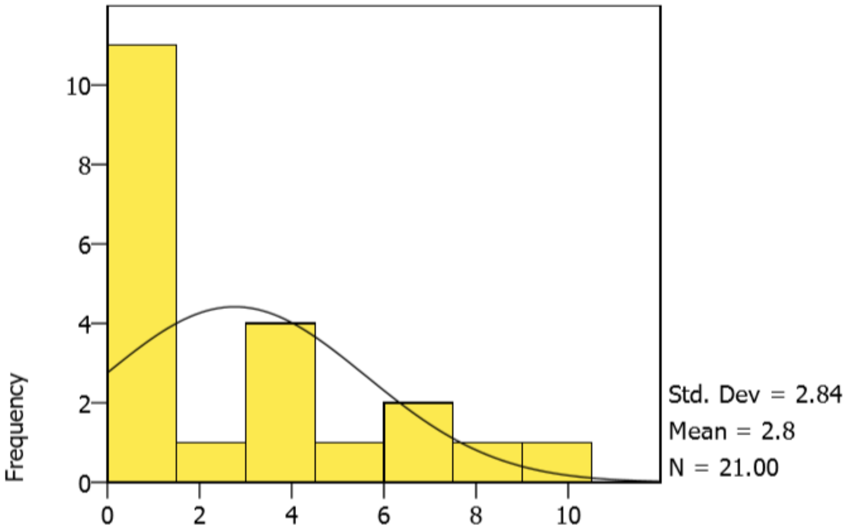


Strengths and Difficulties Questionnaire

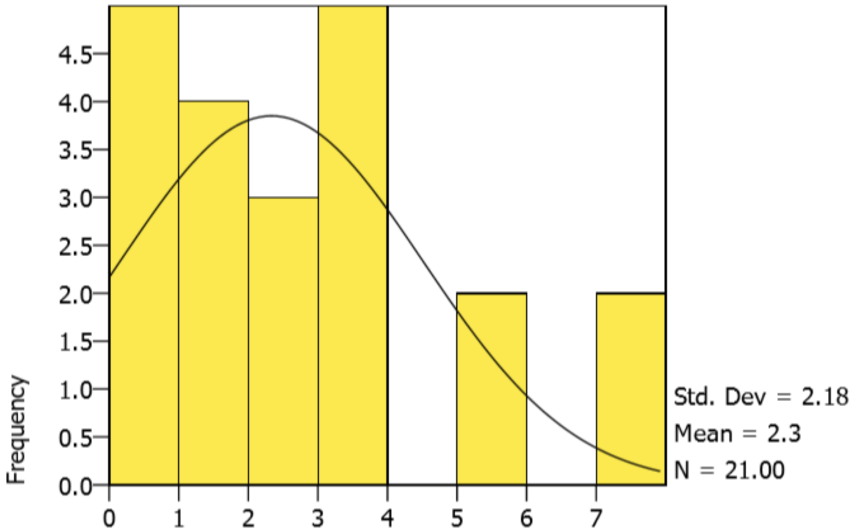
Total



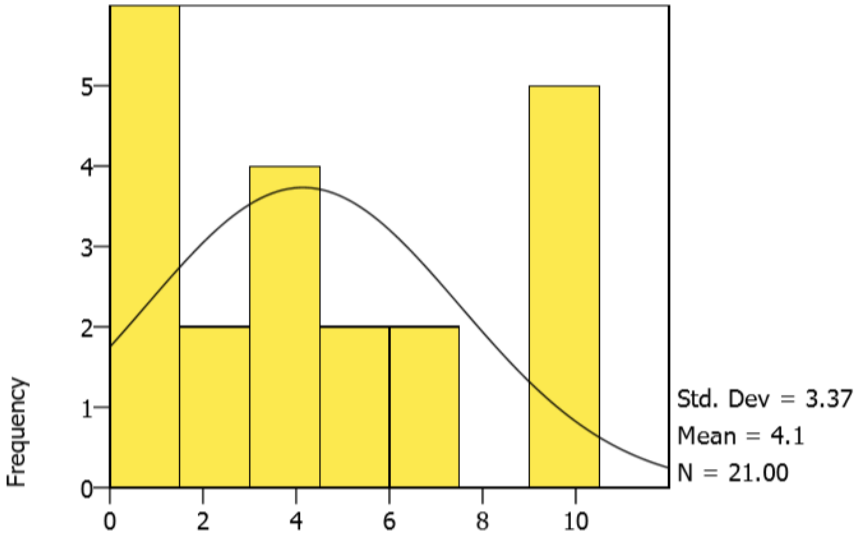
Emotional



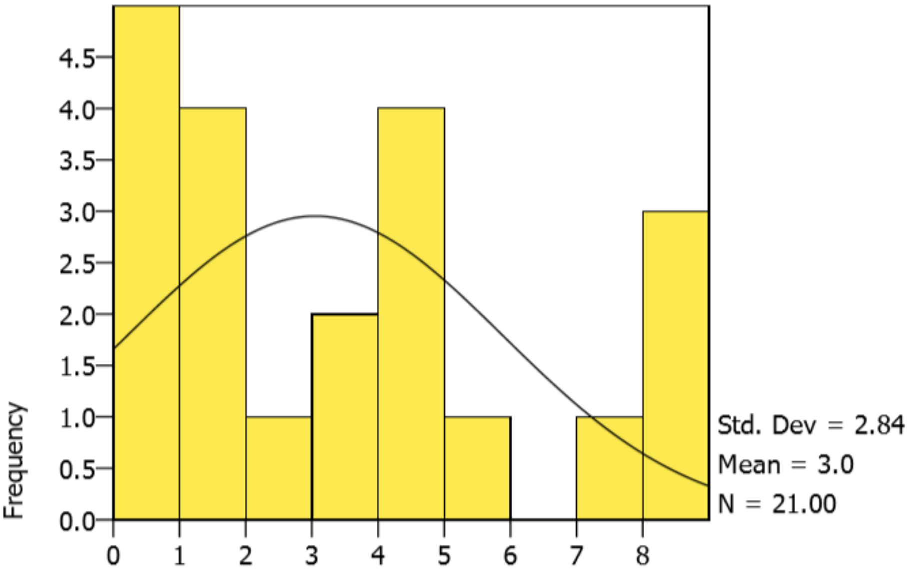
Conduct



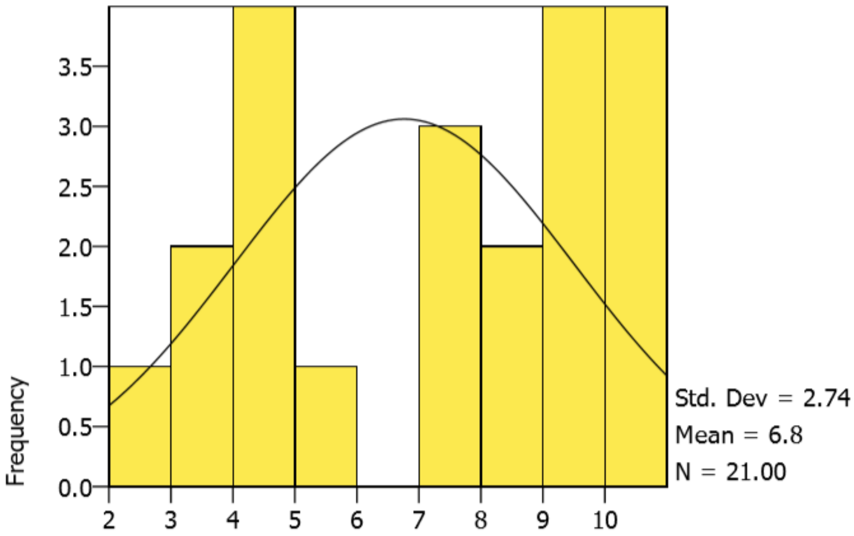
Hyperactivity



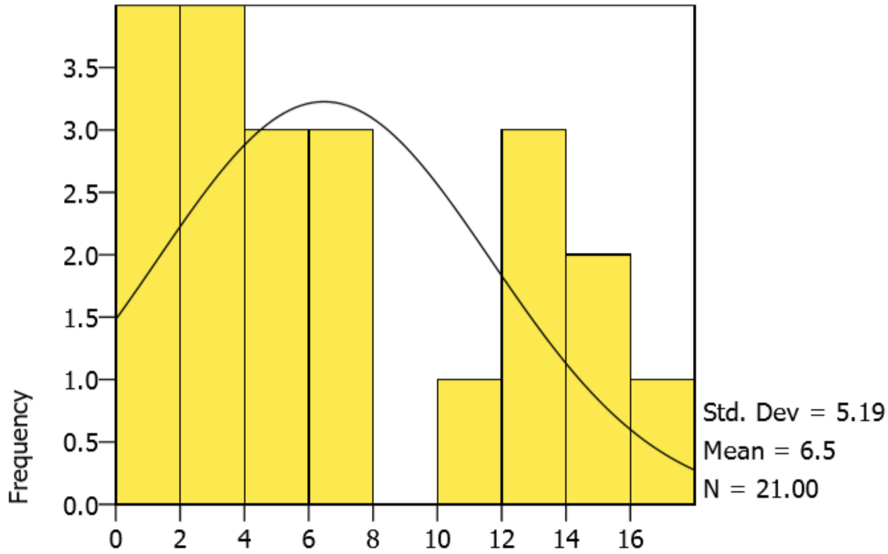
Peer Relations



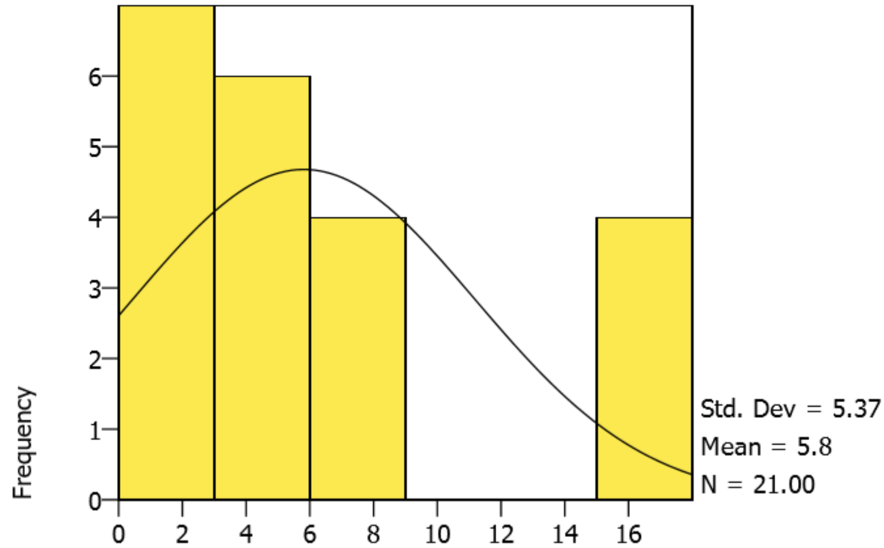
Pro-social



Externalising Scale

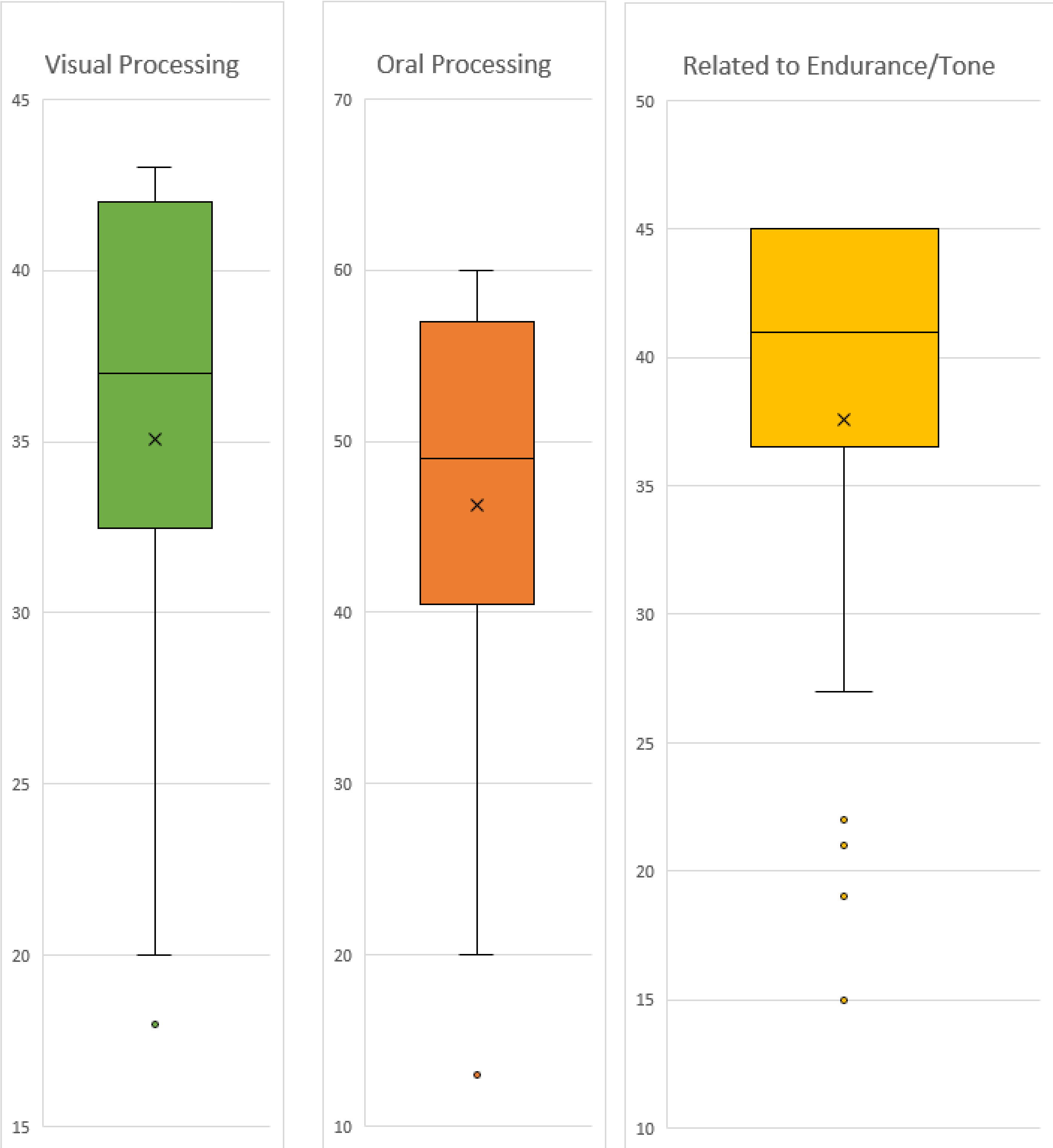


Internalising Scale

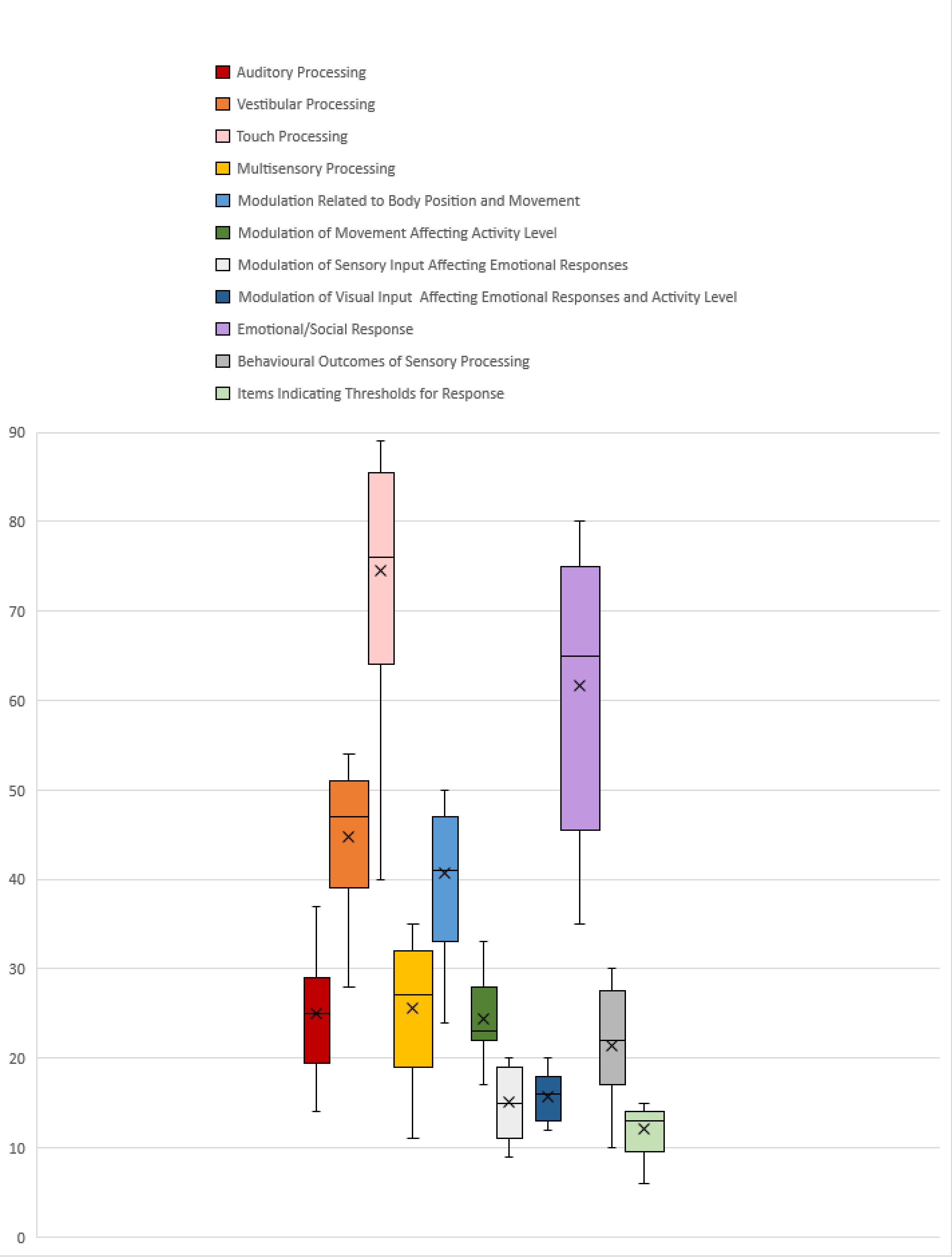


Appendix 12 – Boxplots

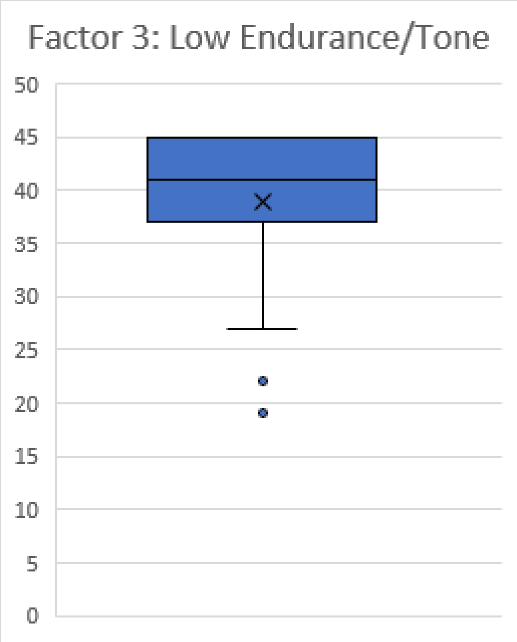
Sensory Profile Caregiver Questionnaire: Items Analysis (with Outliers)

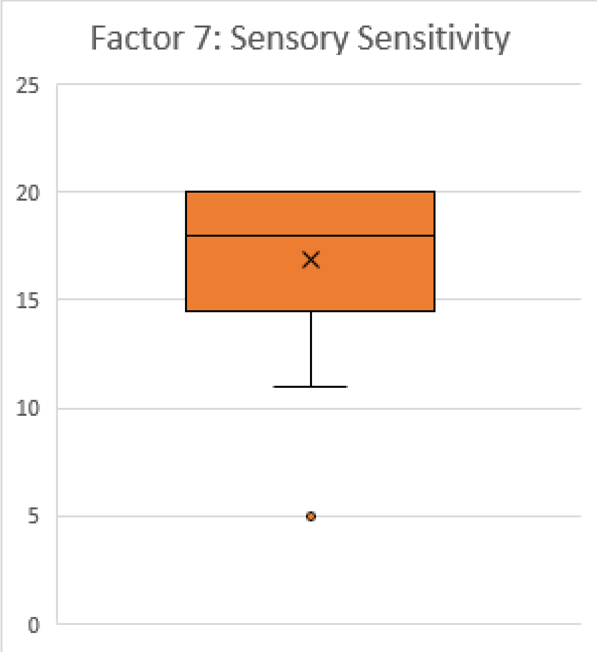


Sensory Profile Caregiver Questionnaire: Items Analysis (without Outliers)

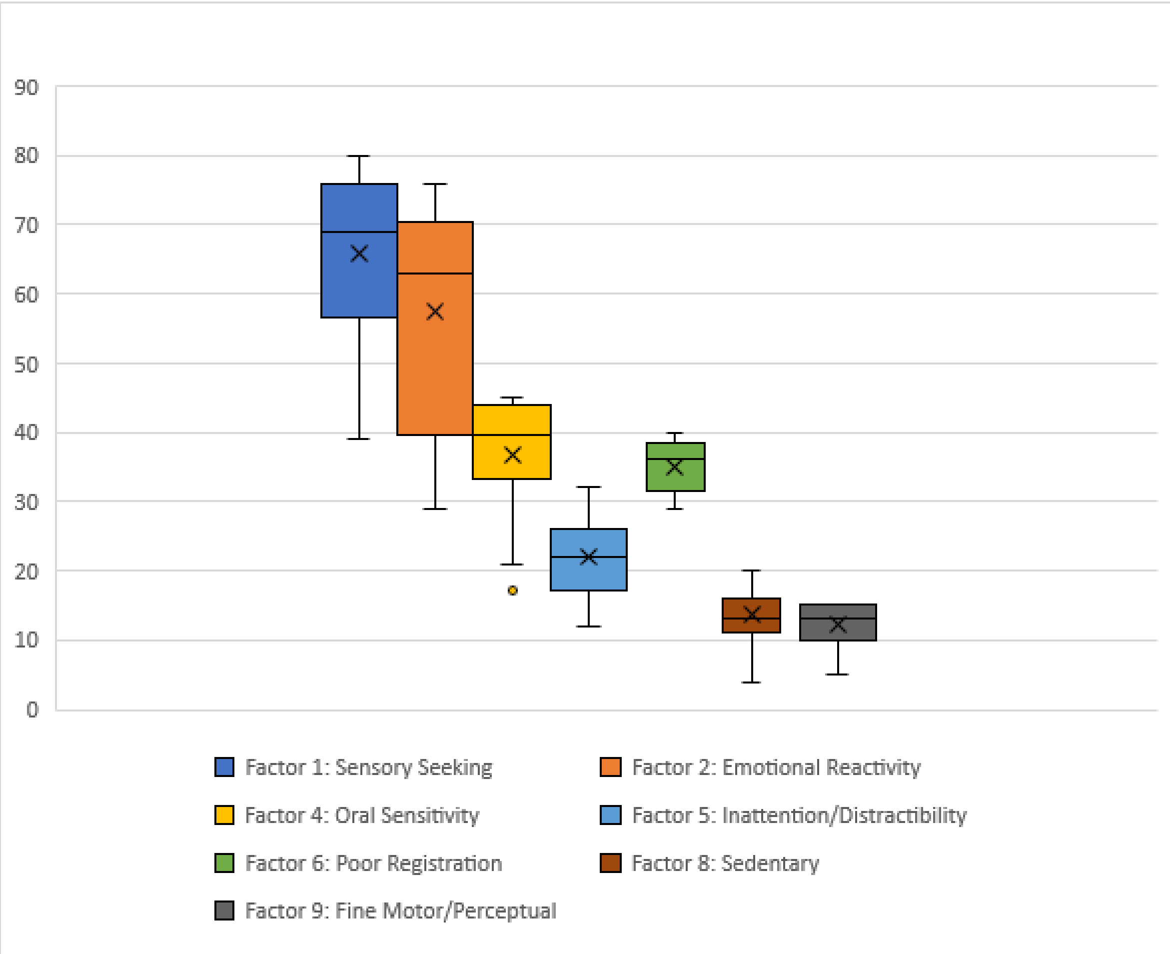


Sensory Profile Caregiver Questionnaire: Factor Analysis (with Outliers)

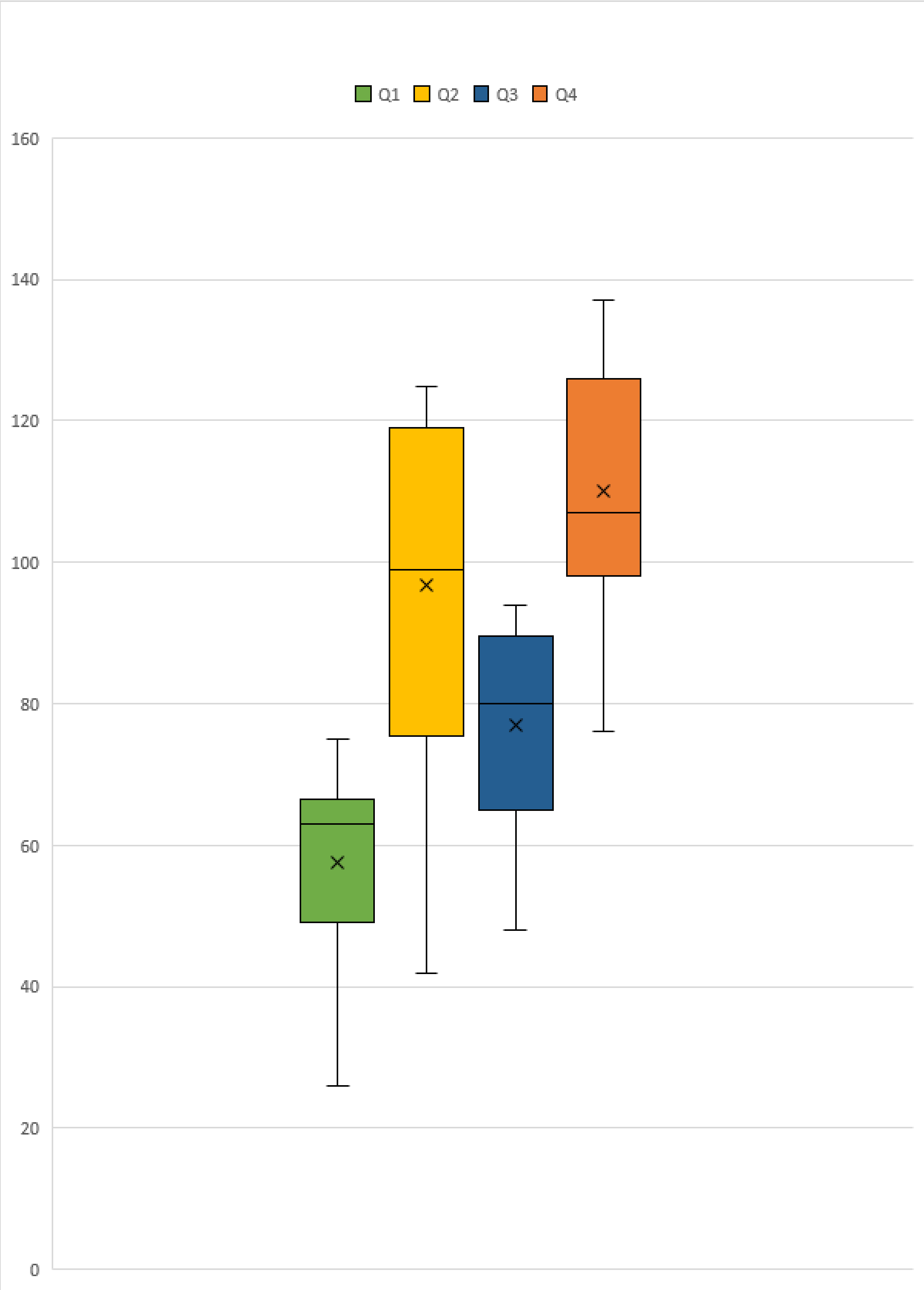




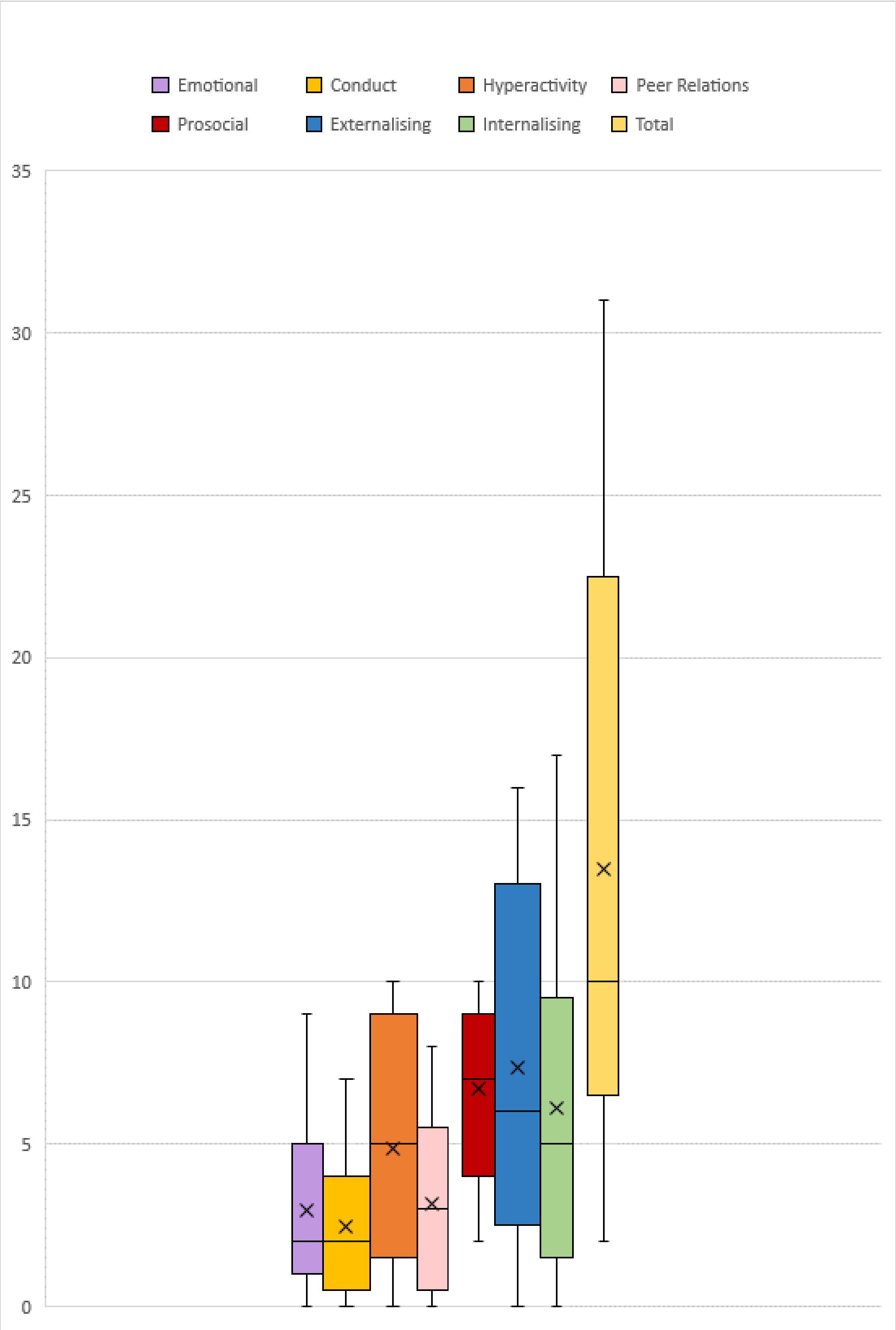
Sensory Profile Caregiver Questionnaire: Factor Analysis (without Outliers)



Sensory Profile Caregiver Questionnaire: Quadrant Analysis

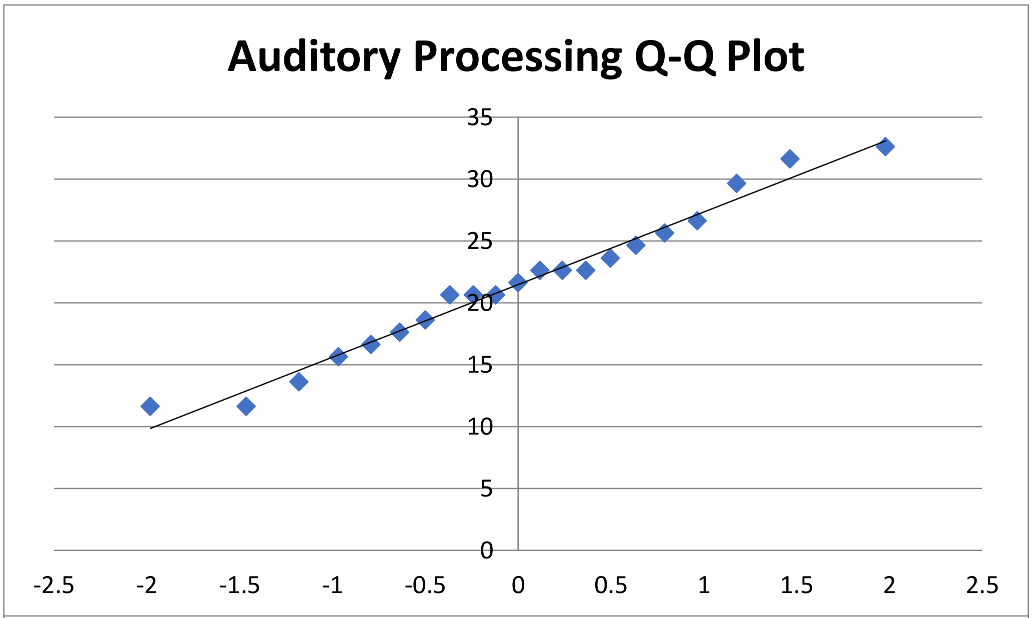


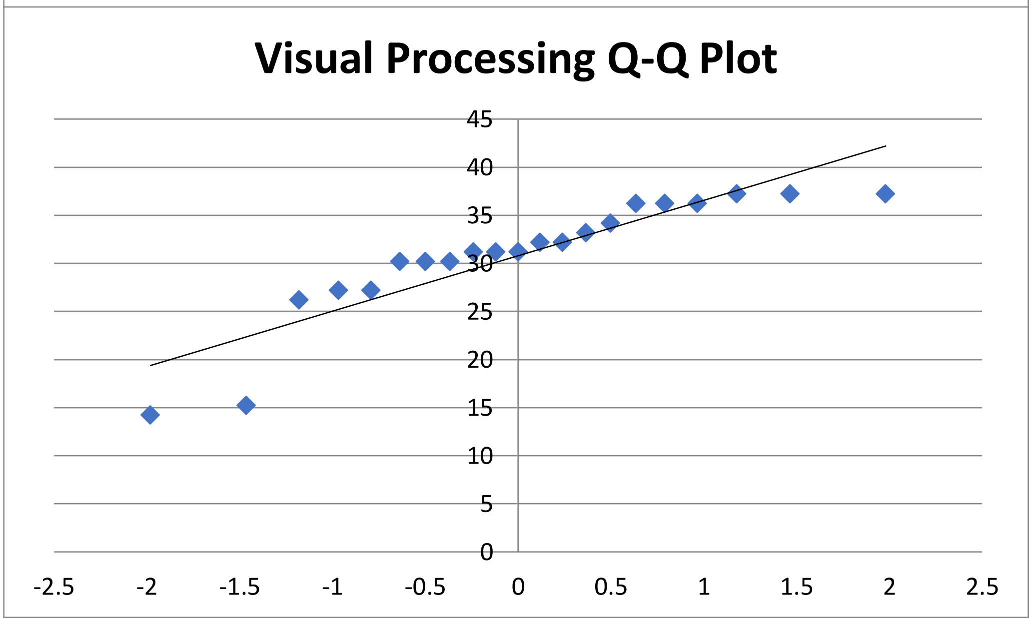
Strengths and Difficulties Questionnaire

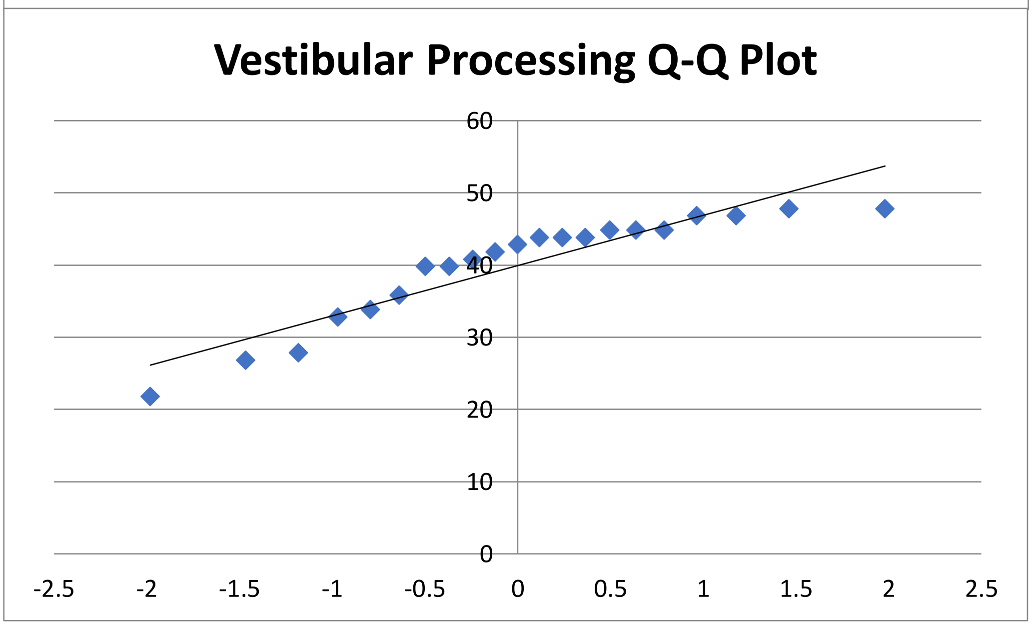


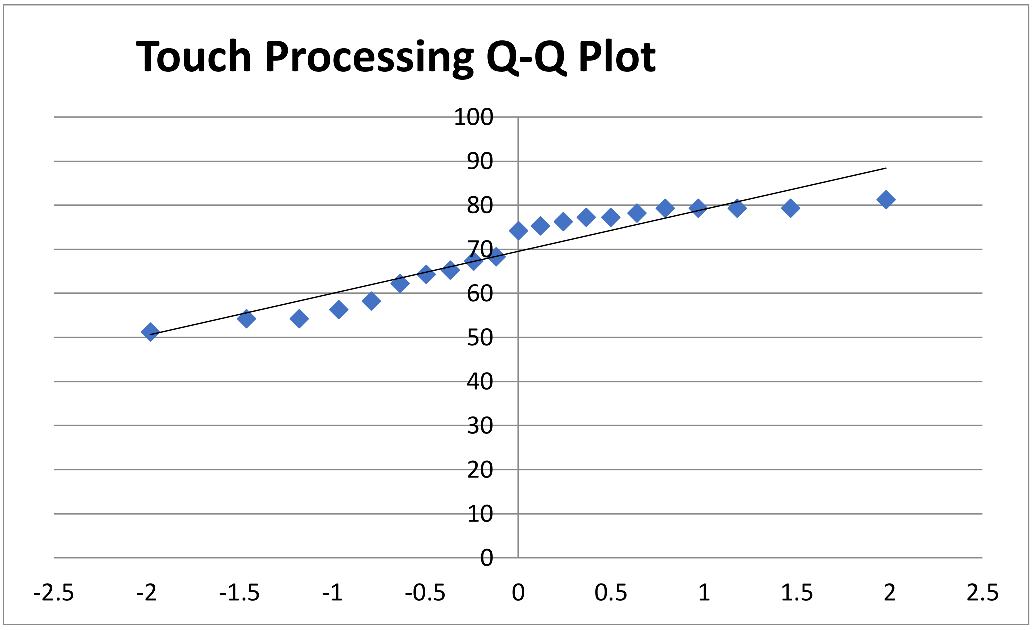
Appendix 13 – Q-Q Plots

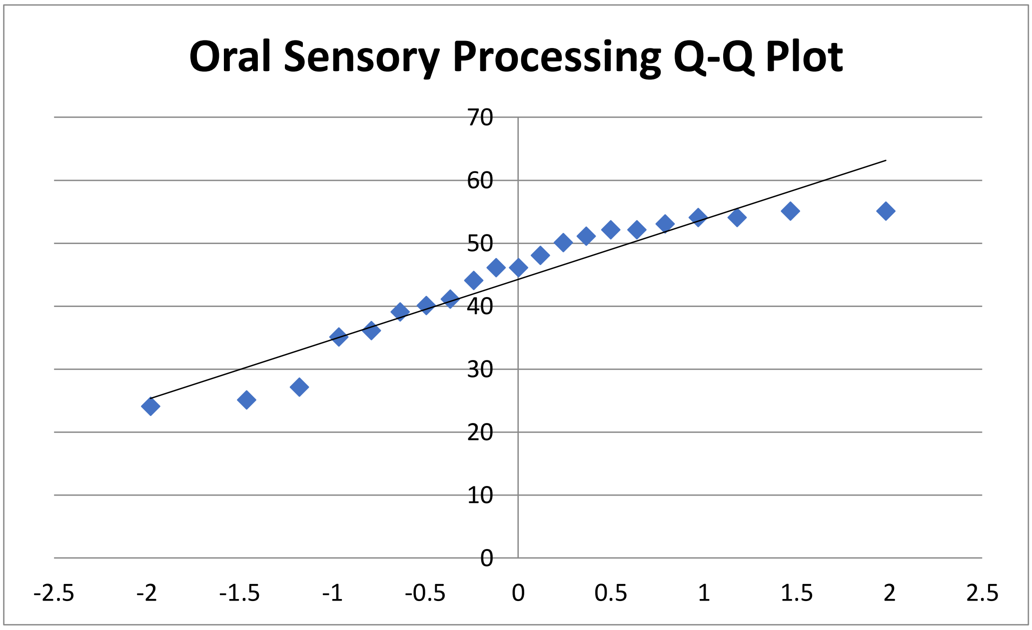
Sensory Profile Caregiver Questionnaire: Items Analysis

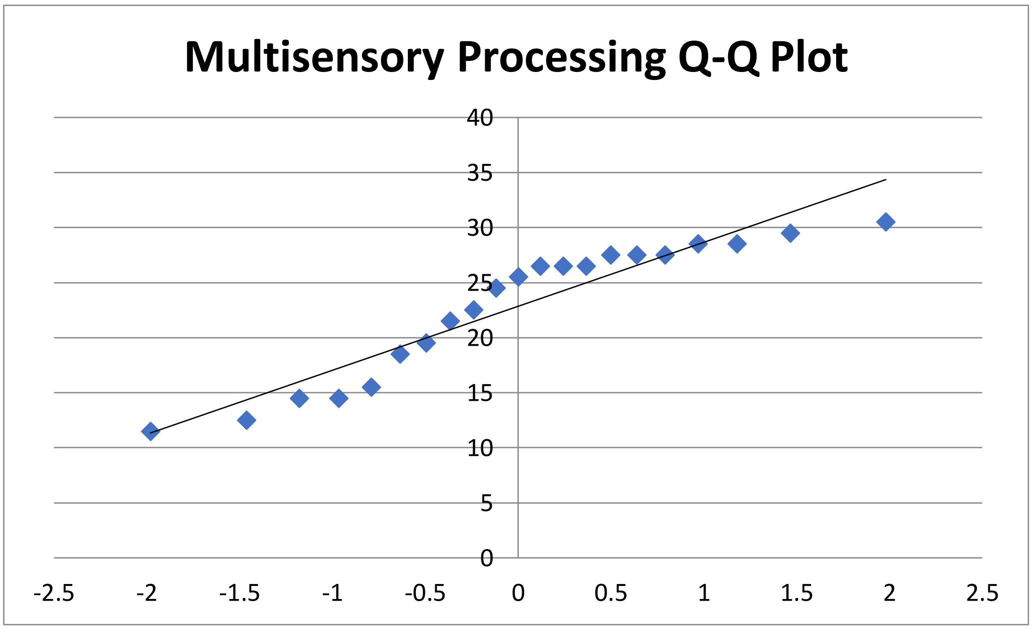


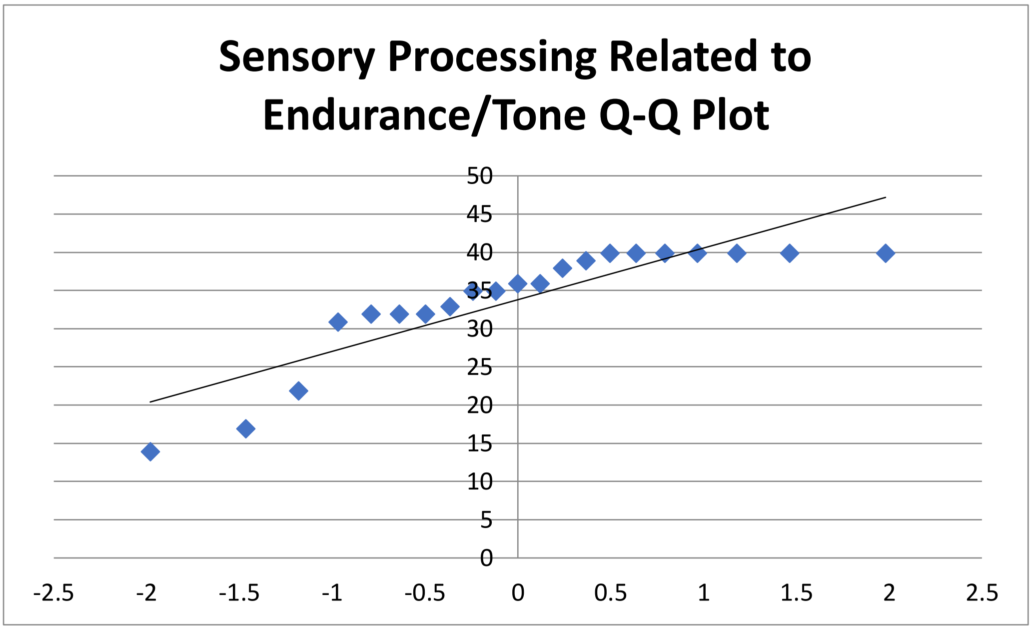


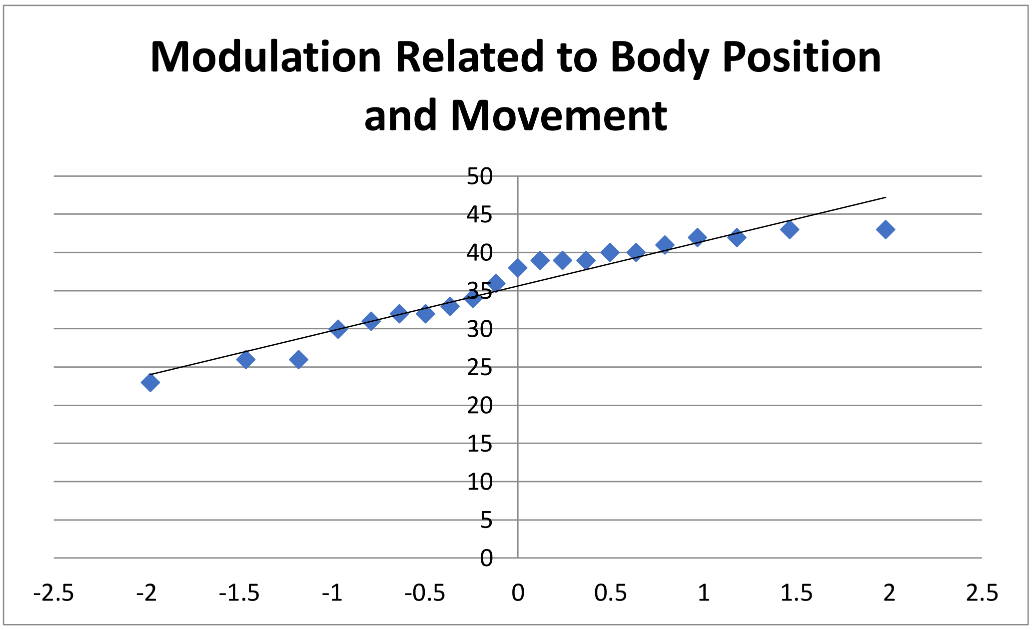


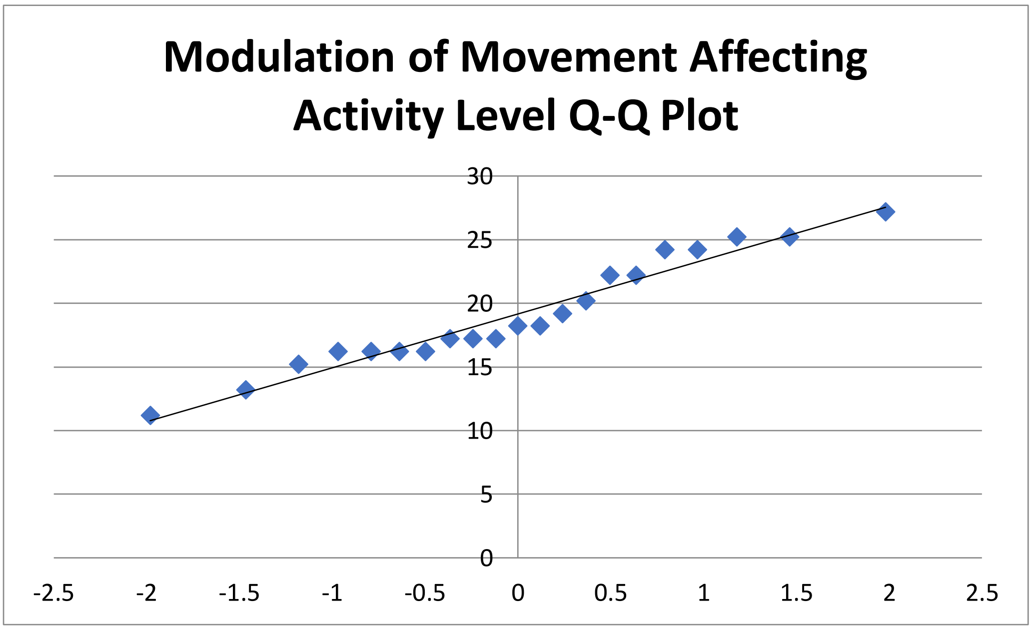

Touch Processing Q-Q Plot
100
90
80
70
60
50
40
30
20
10
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

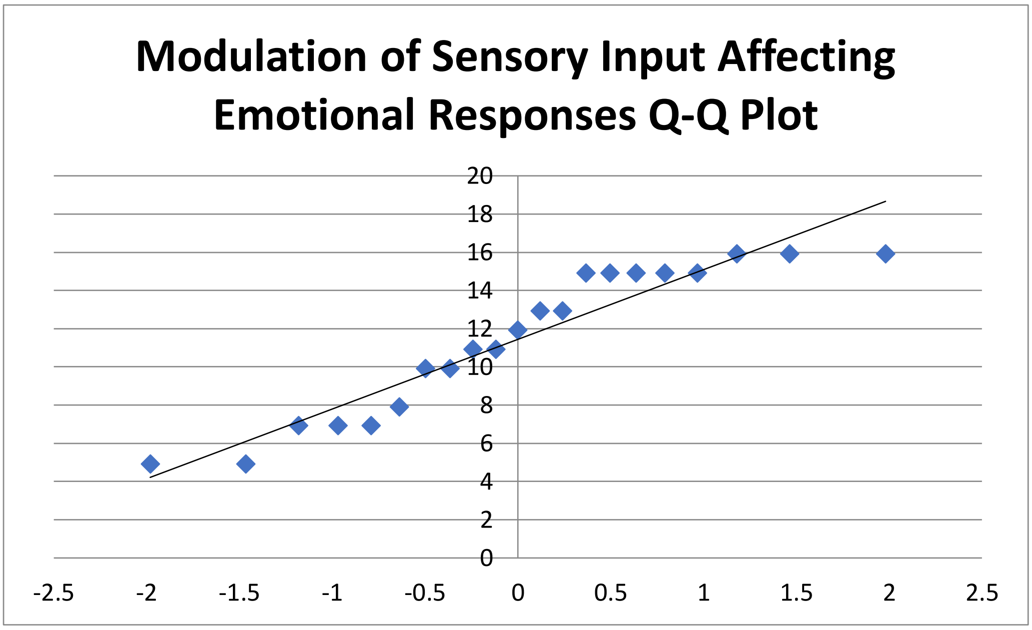

Oral Sensory Processing Q-Q Plot
70
60
50
40
30
20
10
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

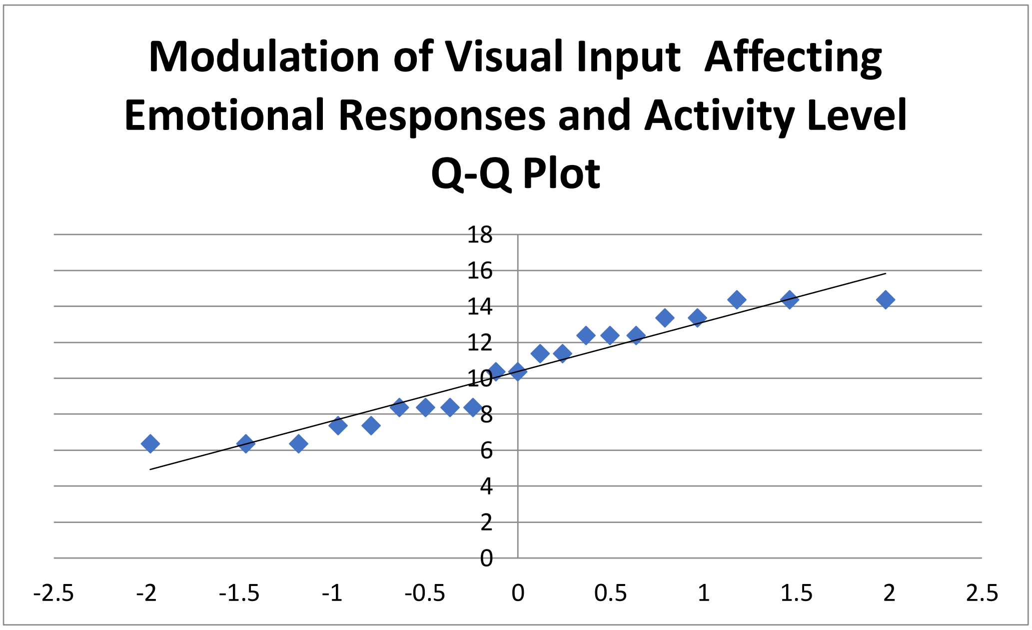

Multisensory Processing Q-Q Plot
40
35
30
25
20
15
10
5
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

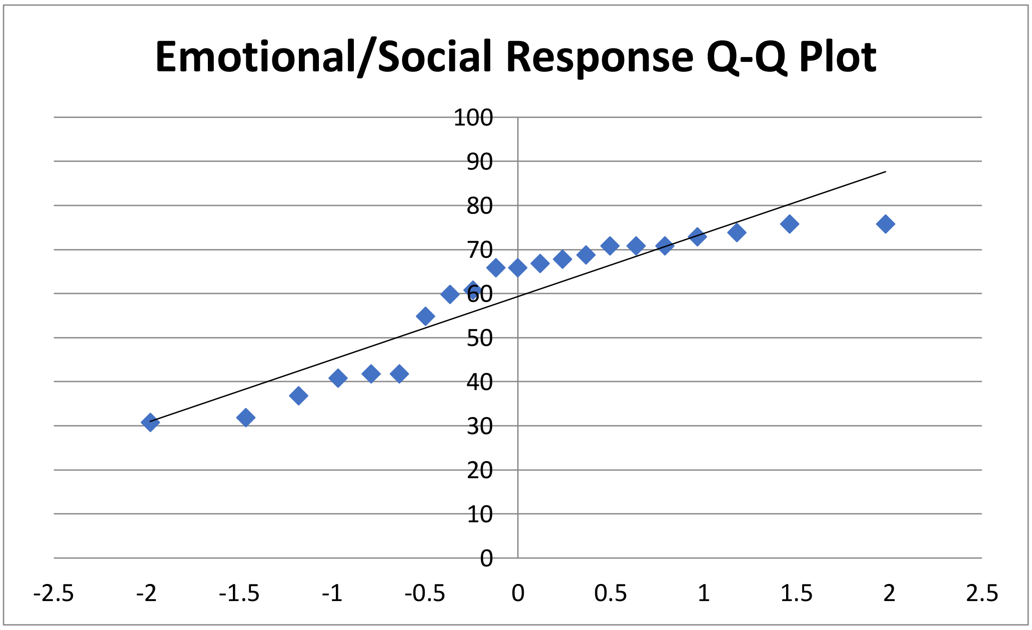

Sensory Processing Related to Endurance/Tone Q-Q Plot
50
45
40
35
30
25
20
15
10
5
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

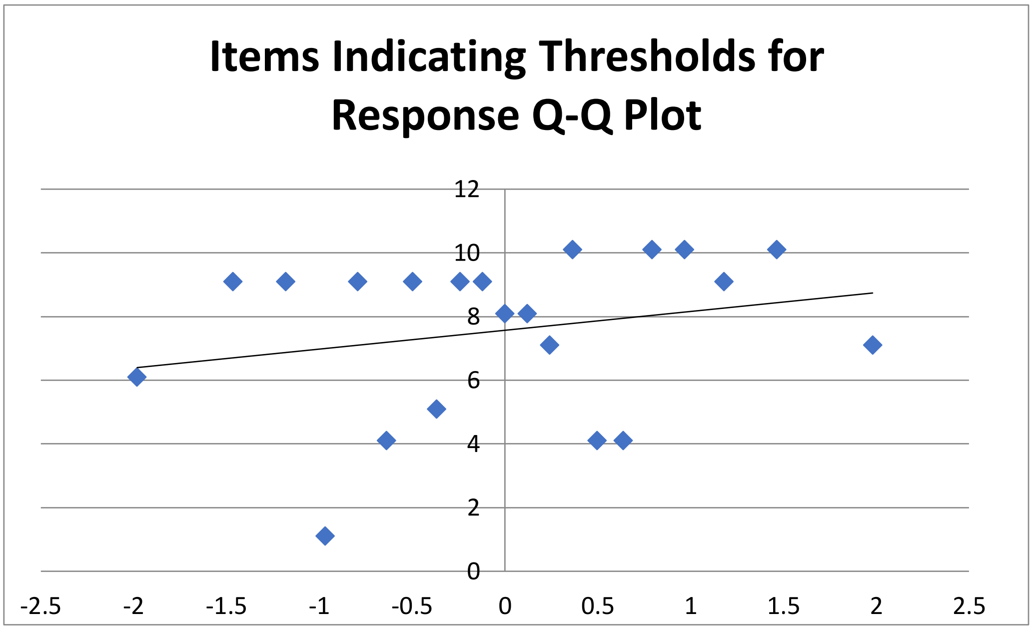

Modulation Related to Body Position and Movement
50
45
40
35
30
25
20
15
10
5
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

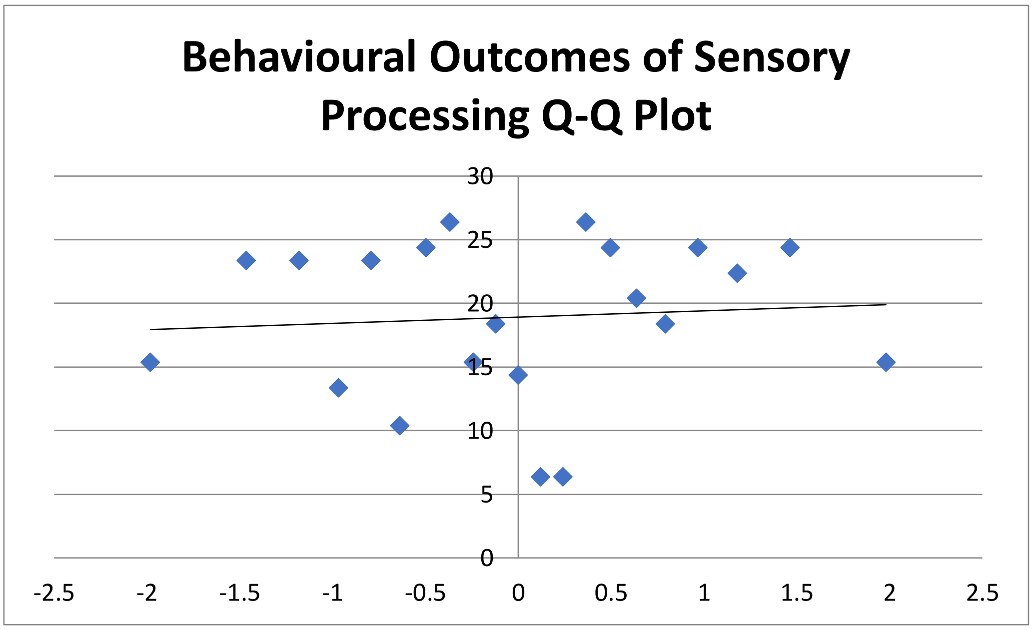

Modulation of Movement Affecting Activity Level Q-Q Plot
30
25
20
15
10
5
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5


Modulation of Sensory Input Affecting Emotional Responses Q-Q Plot
20
18
16
14
12
10
8
6
4
2
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

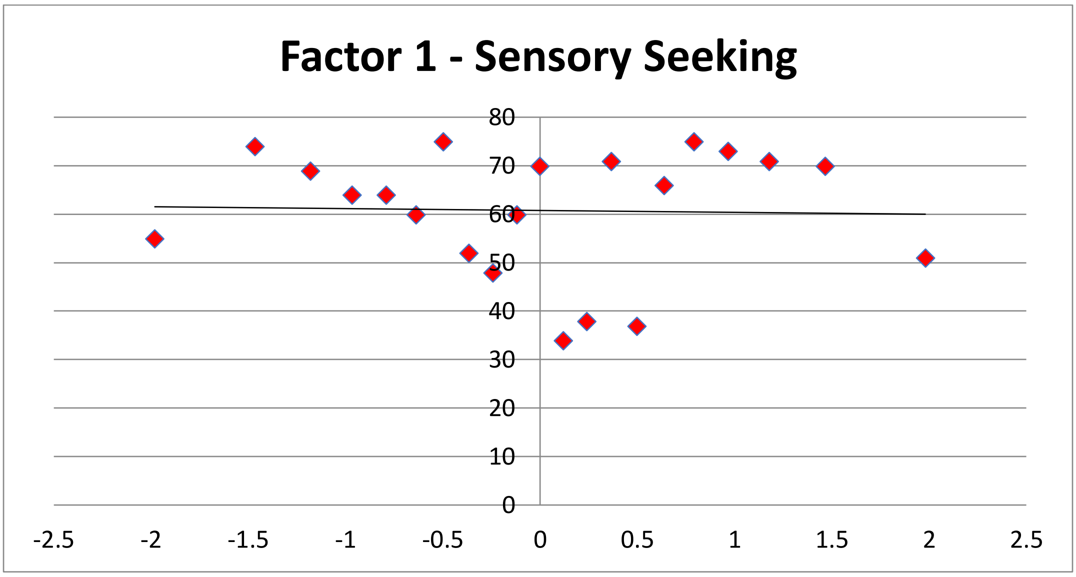

Modulation of Visual Input Affecting Emotional Responses and Activity Level Q-Q Plot
18
16
14
12
10
8
6
4
2
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

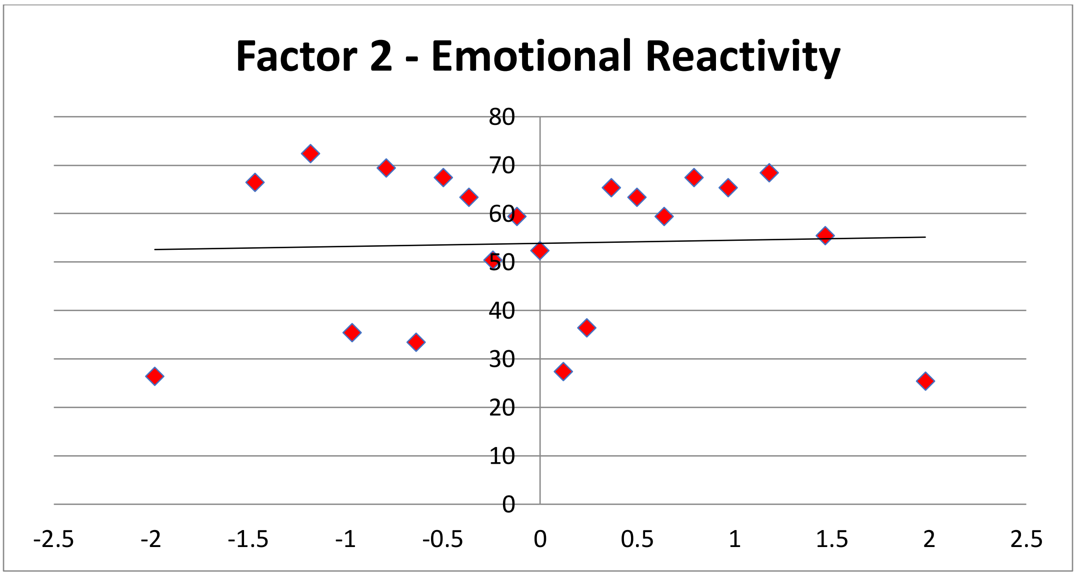

Emotional/Social Response Q-Q Plot
100
90
80
70
60
50
40
30
20
10
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

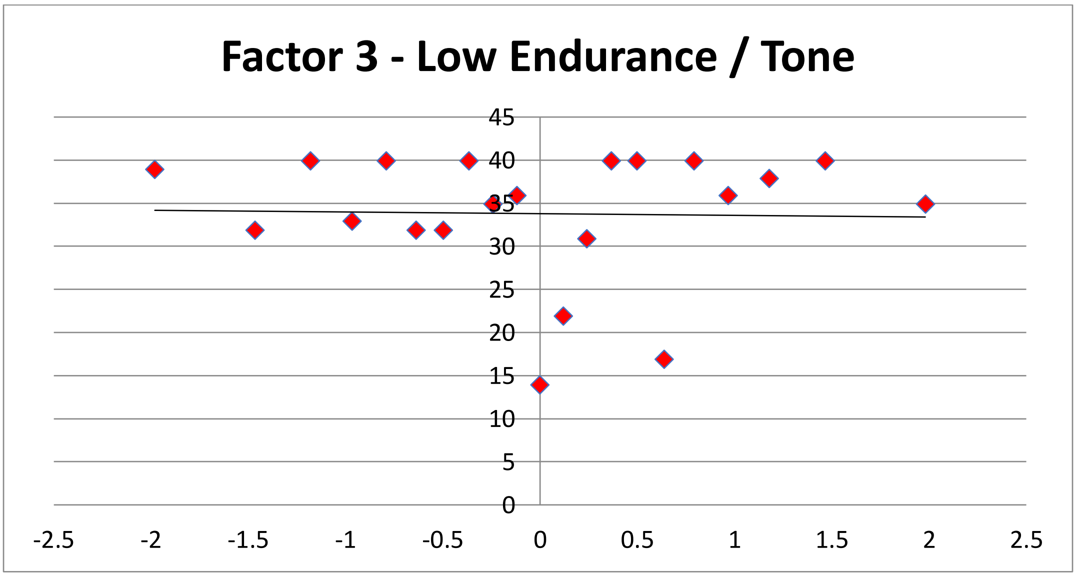

Items Indicating Thresholds for Response Q-Q Plot
0
2
4
6
8
10
12
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

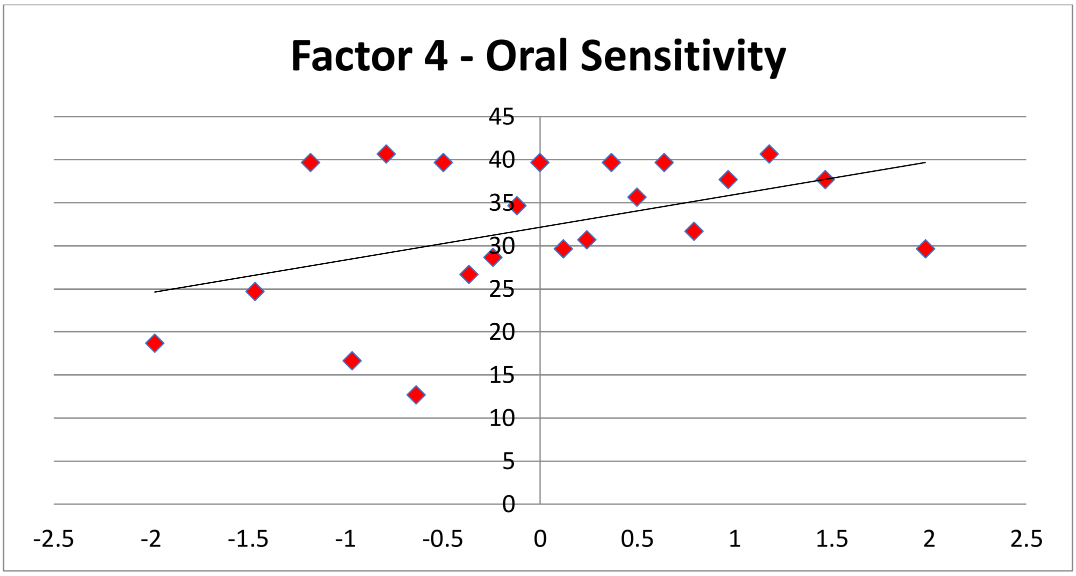

Behavioural Outcomes of Sensory Processing Q-Q Plot
0
5
10
15
20
25
30
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

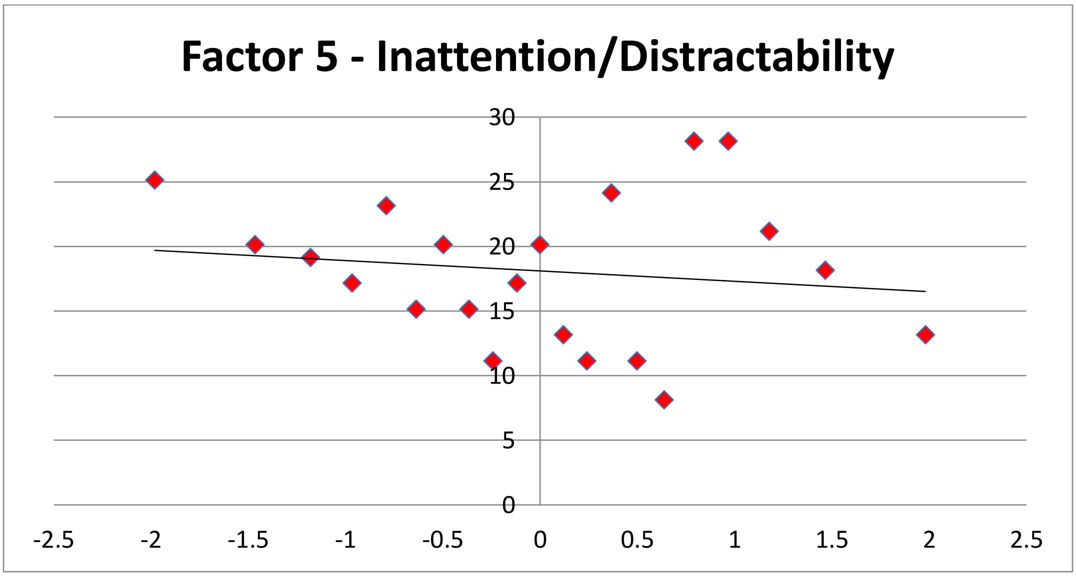
Sensory Profile Caregiver Questionnaire: Factor Analysis

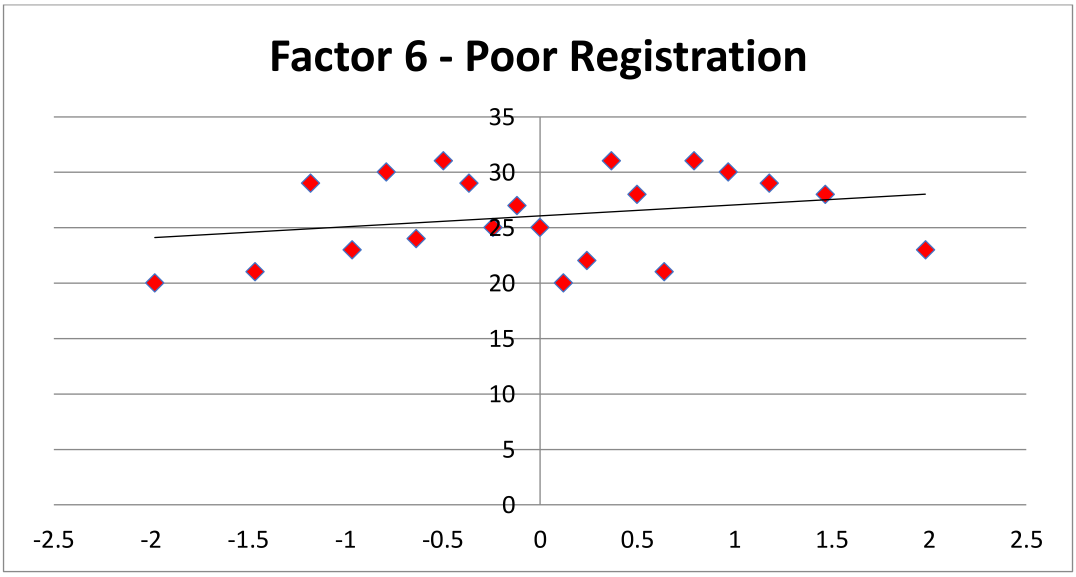


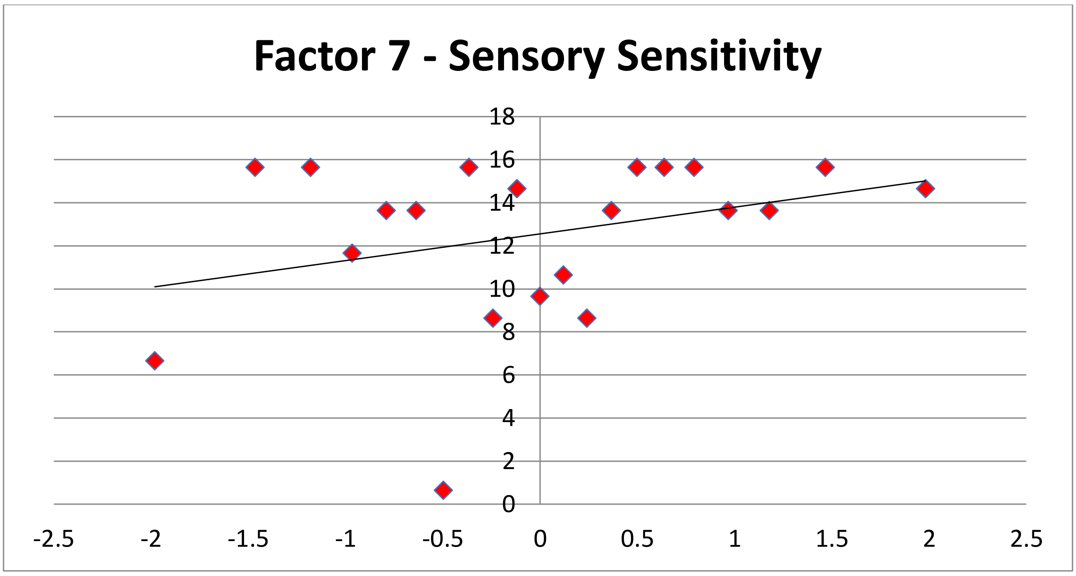


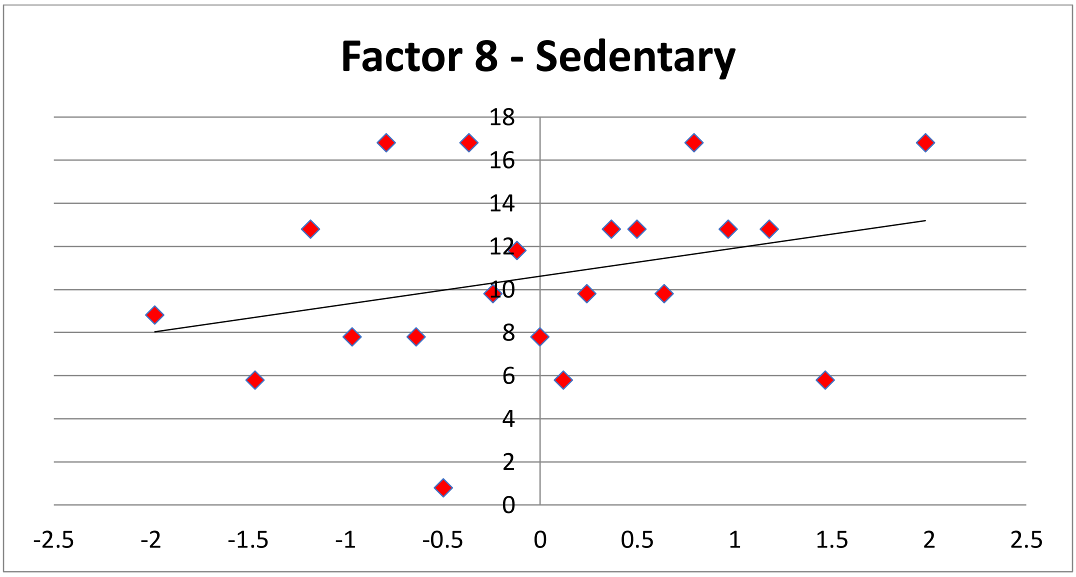


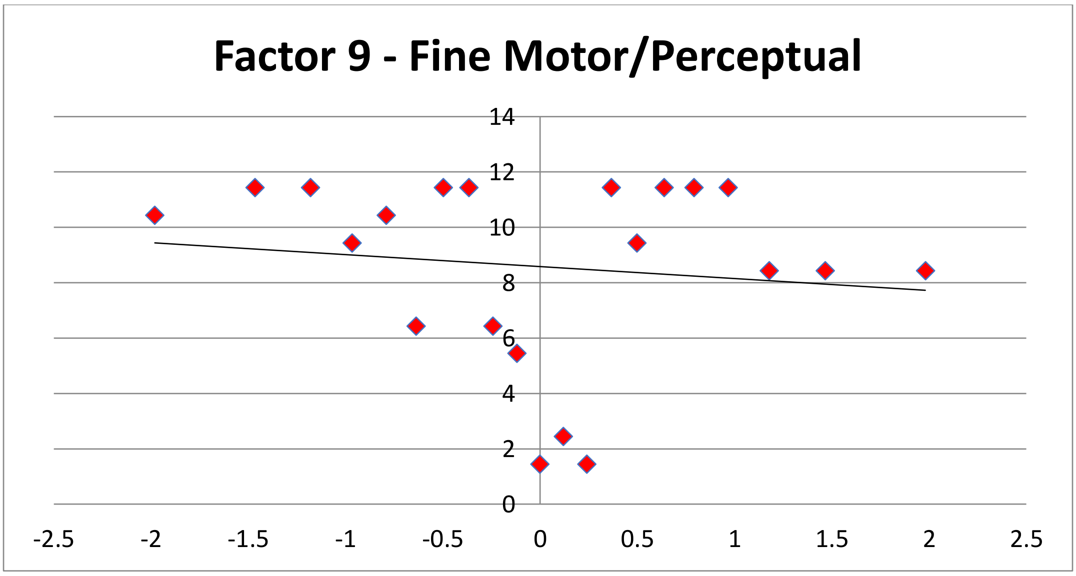

Factor 4 - Oral Sensitivity
45
40
35
30
25
20
15
10
5
0
-2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5


Factor 5 - Inattention/Distractability
30
25
20
15
10
5
0
-2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5

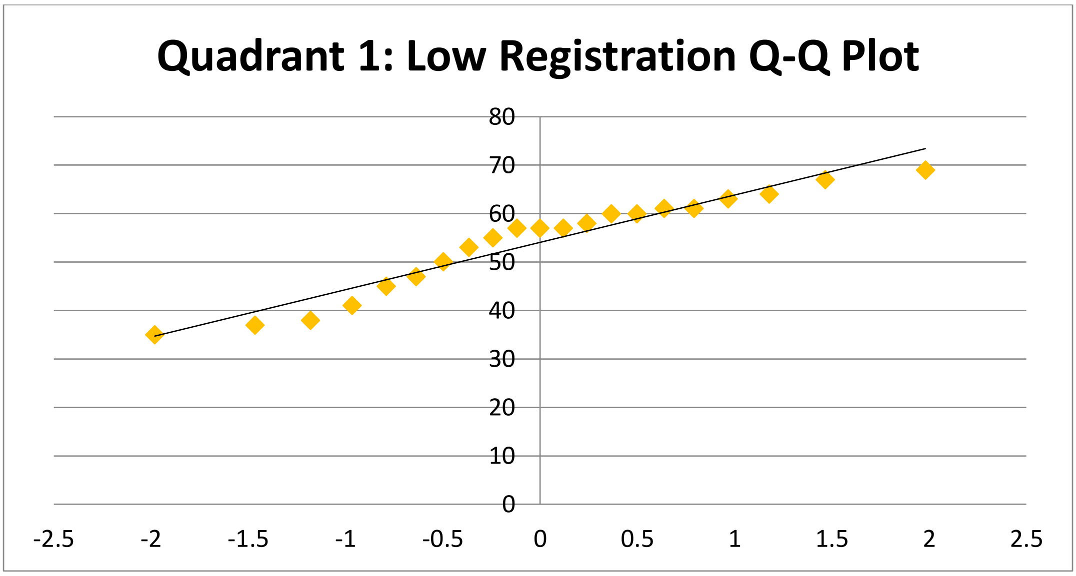

Factor 6 - Poor Registration
35
30
25
20
15
10
5
0
-2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5

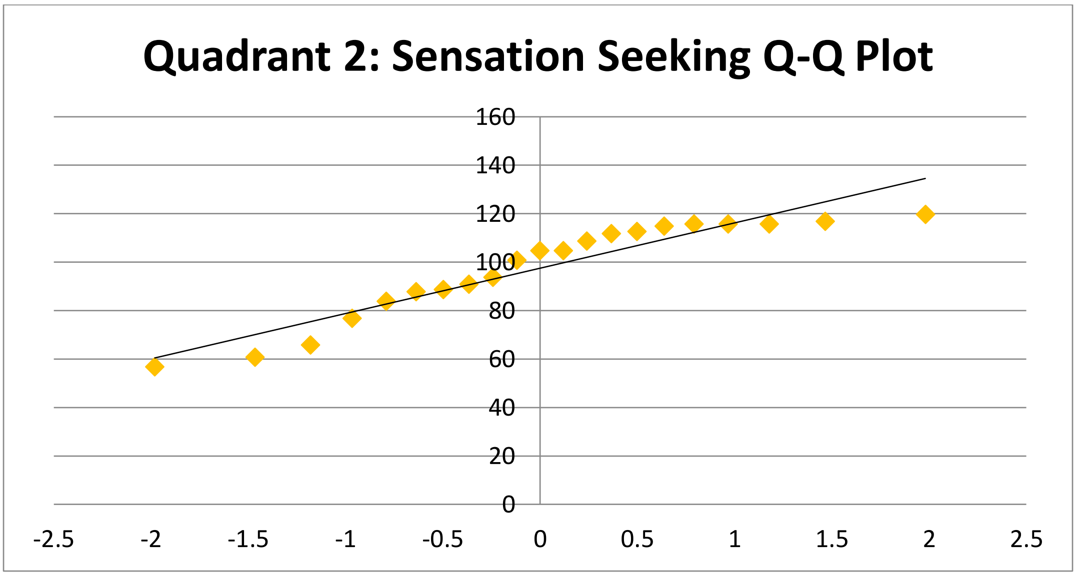

Factor 7 - Sensory Sensitivity
18
16
14
12
10
8
6
4
2
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

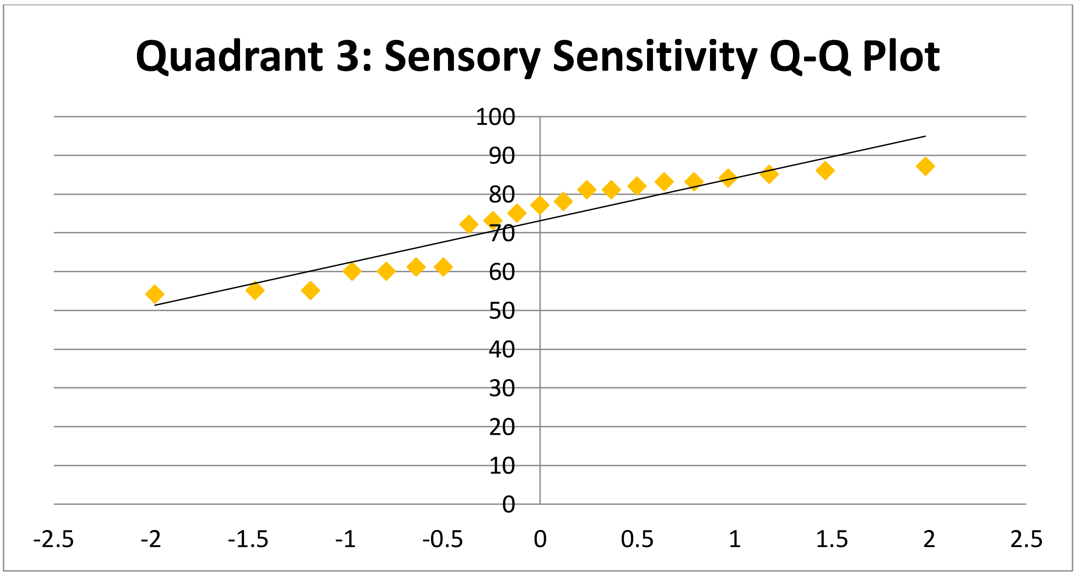

Factor 8 - Sedentary
18
16
14
12
10
8
6
4
2
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

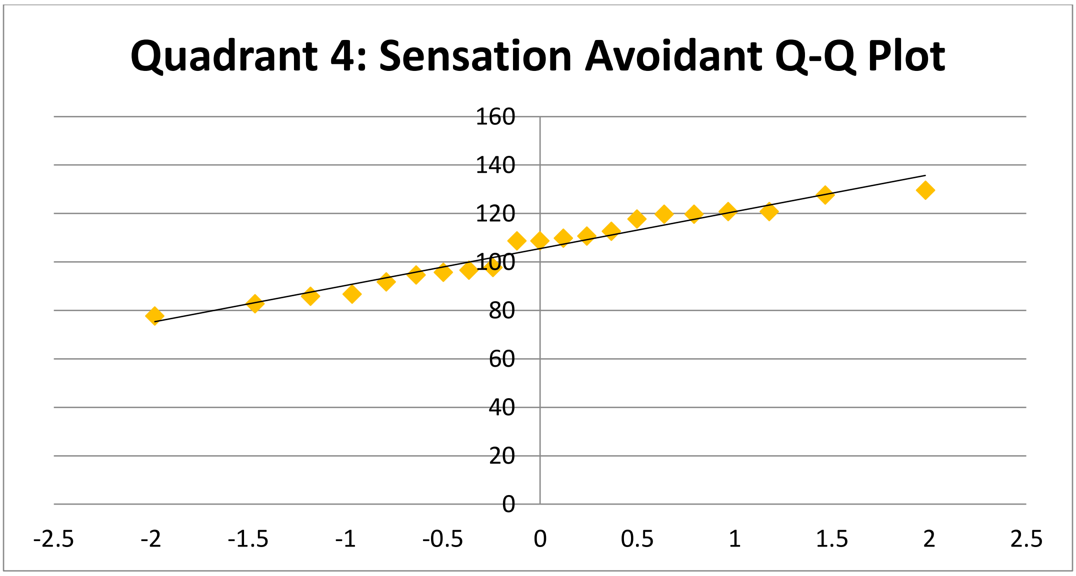

Factor 9 - Fine Motor/Perceptual
14
12
10
8
6
4
2
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

Sensory Profile Caregiver Questionnaire: Quadrant Analysis

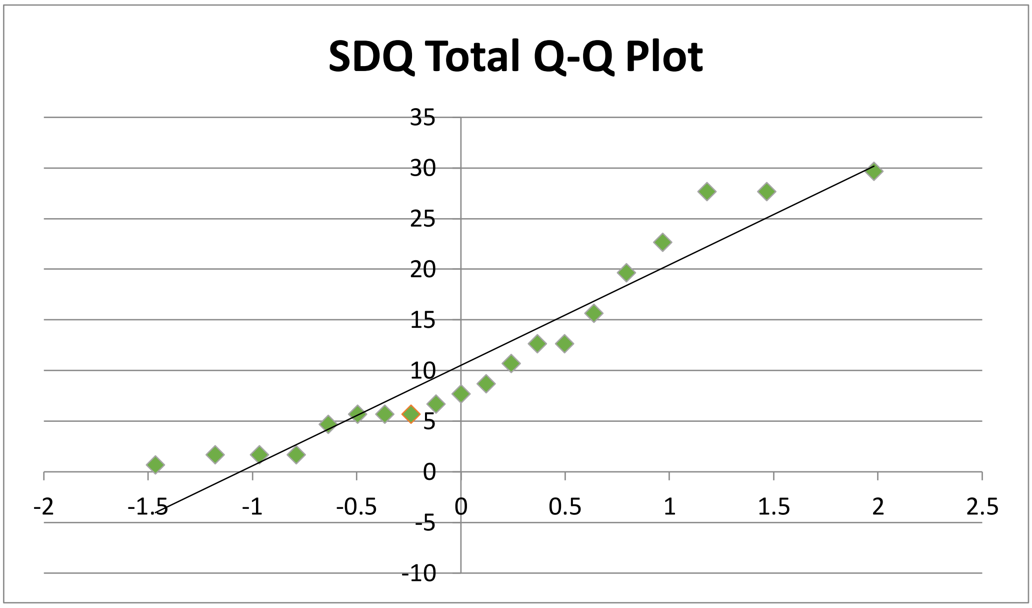


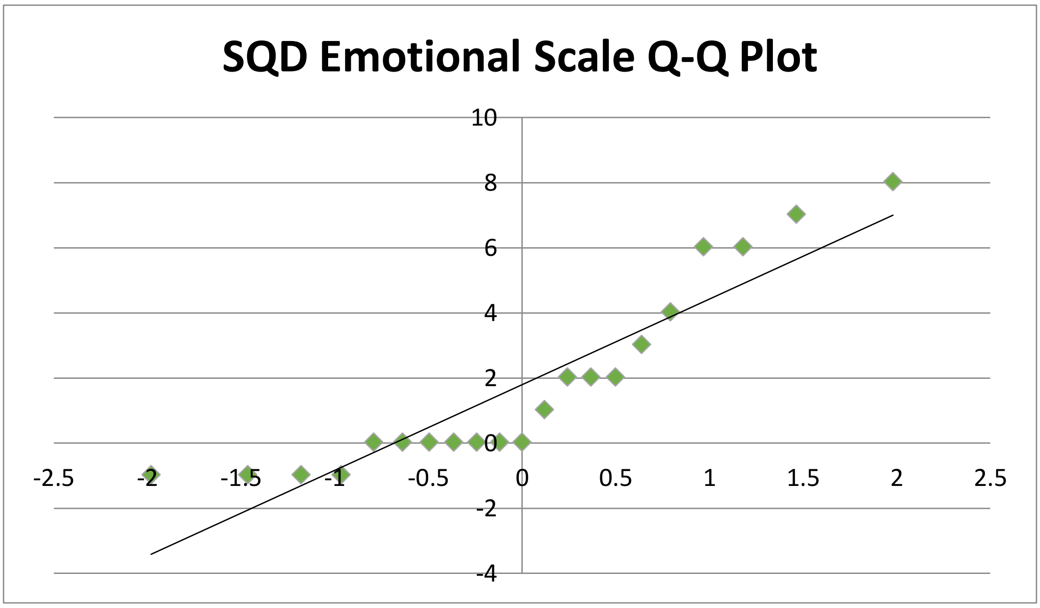


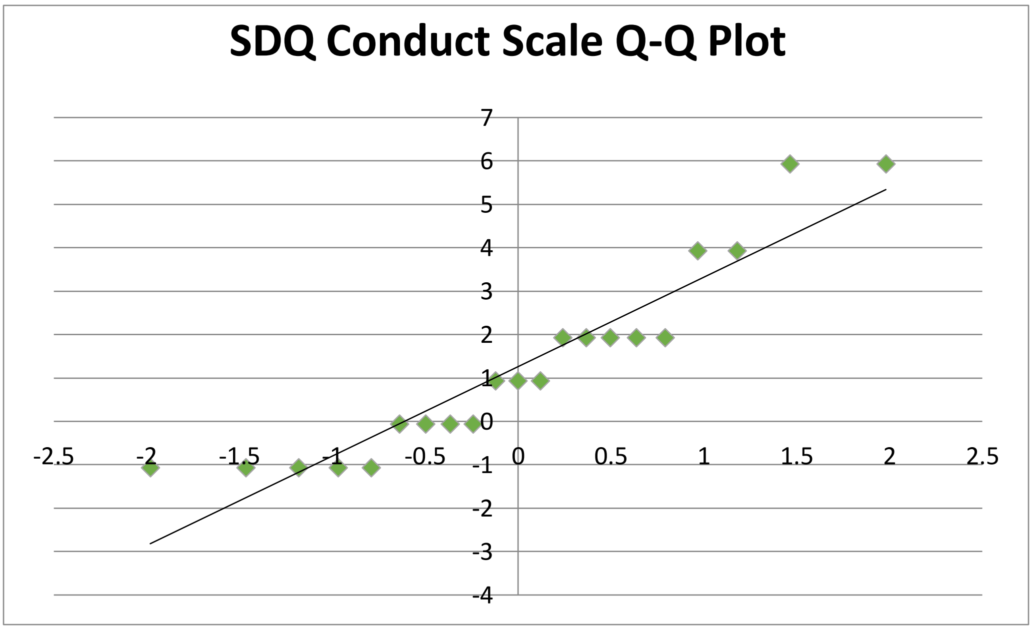


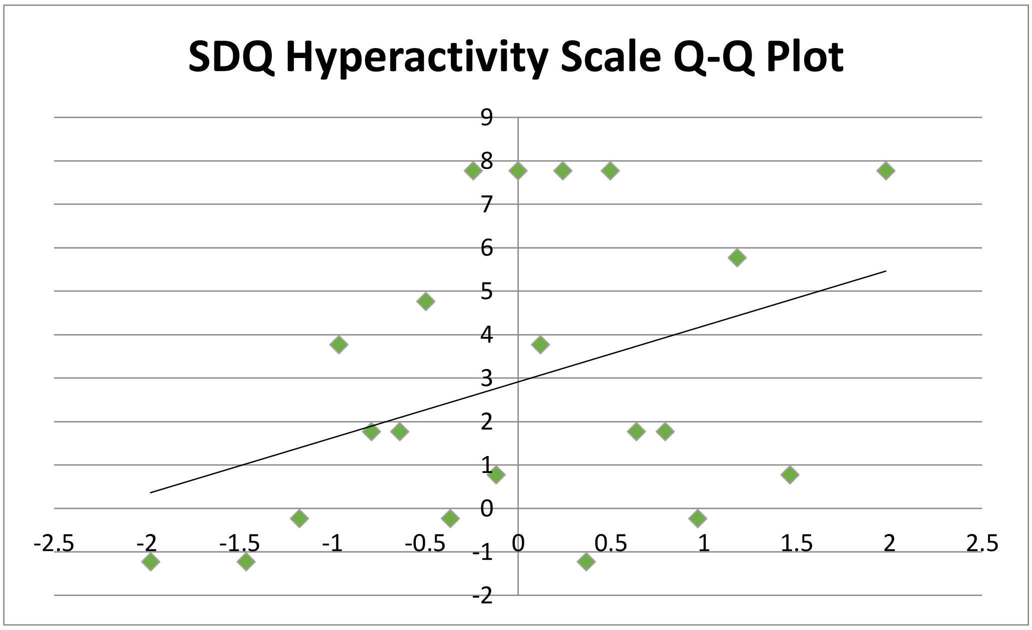

Quadrant 4: Sensation Avoidant Q-Q Plot
160
140
120
100
80
60
40
20
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

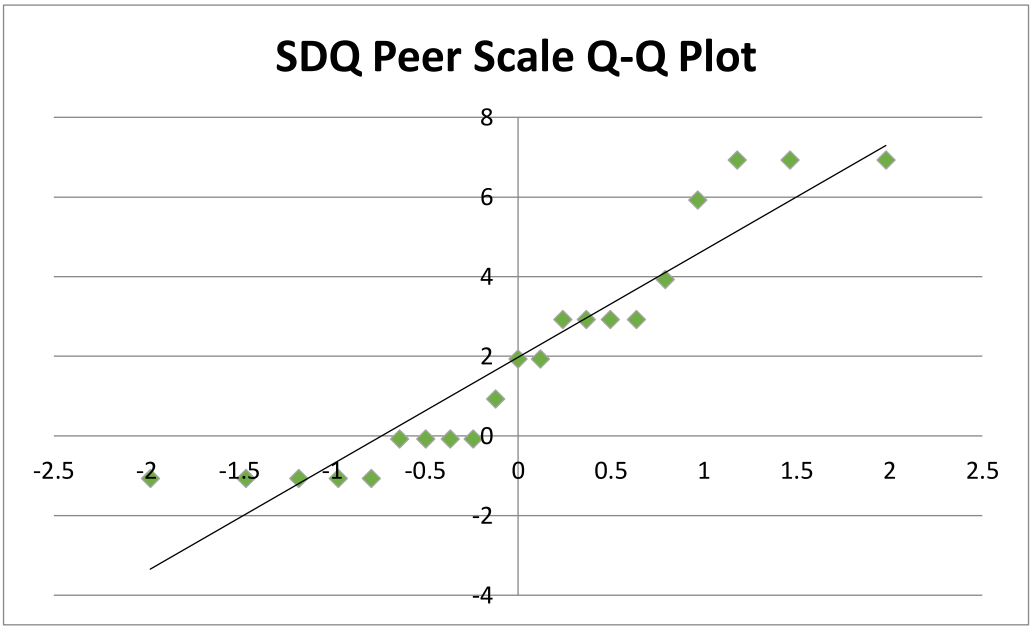
Strengths and Difficulties Questionnaire

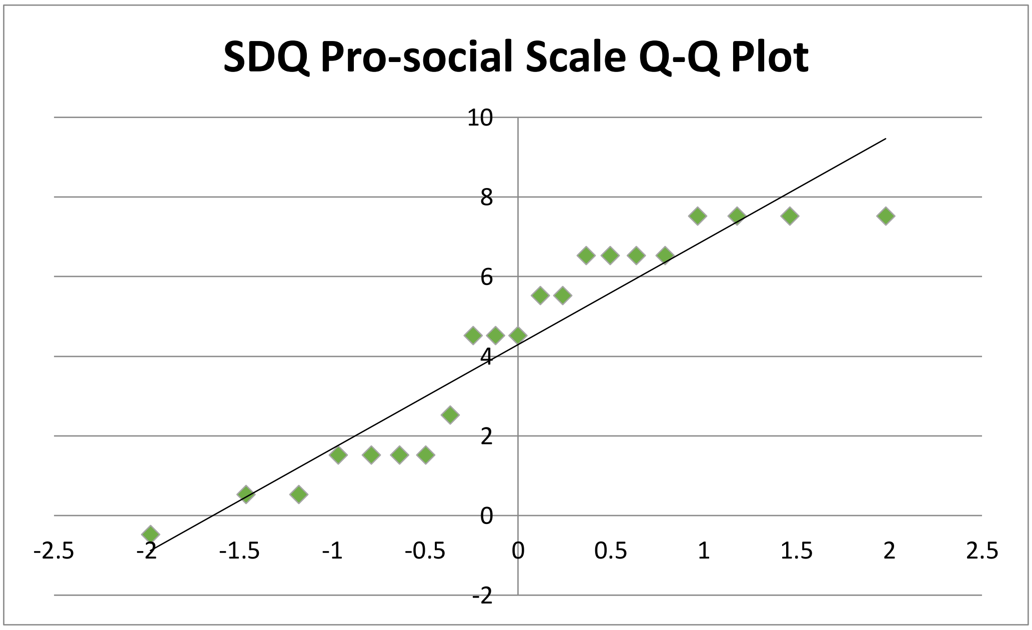


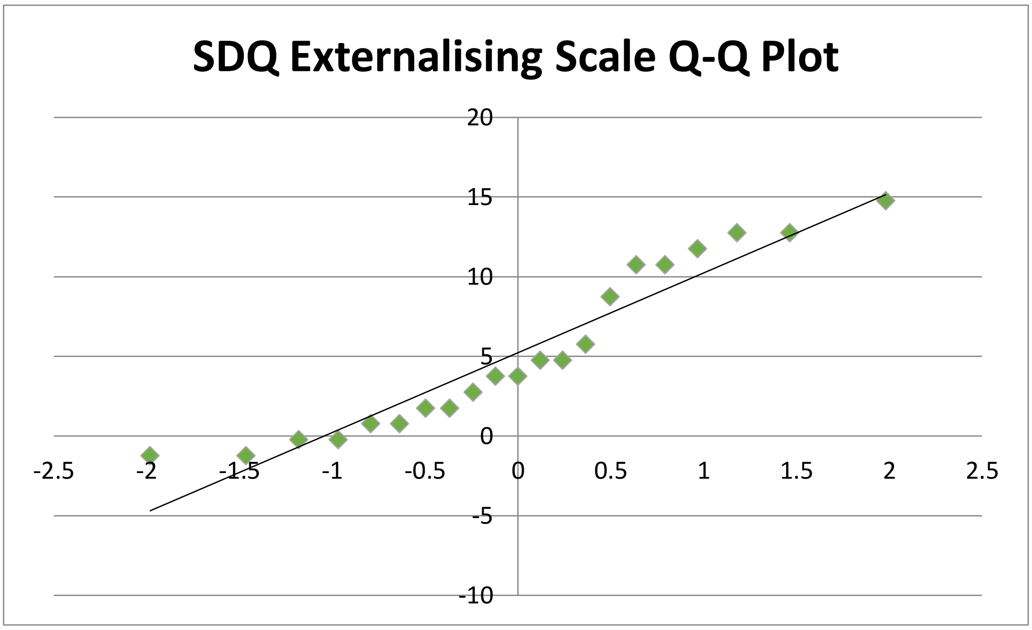


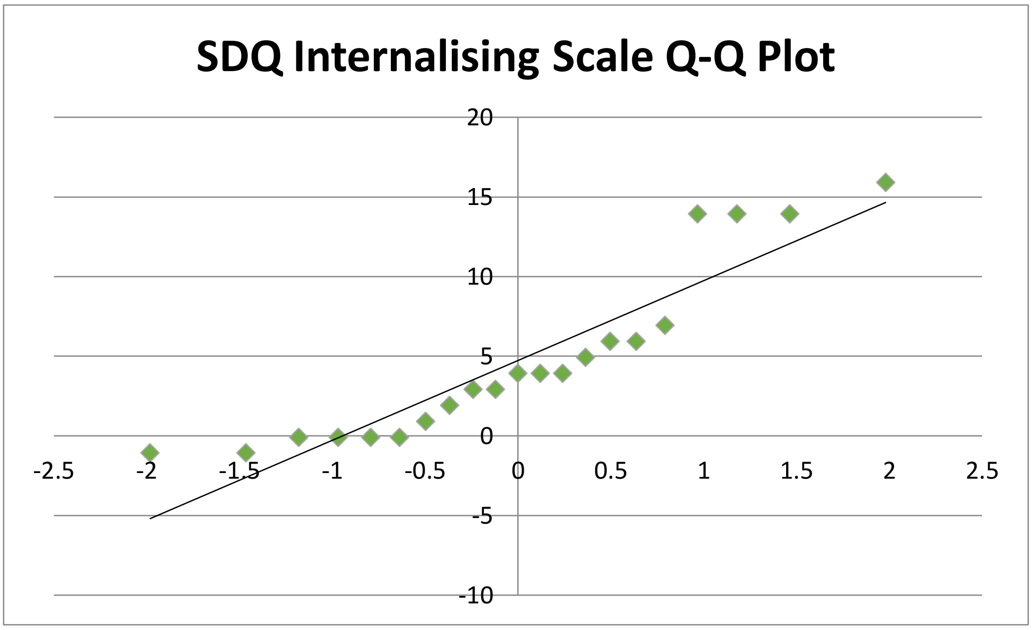



SDQ Hyperactivity Scale Q-Q Plot
9
8
7
6
5
4
3
2
1
0
-1
-2
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5


SDQ Peer Scale Q-Q Plot
8
6
4
2
0
-2
-4
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5


SDQ Pro-social Scale Q-Q Plot
10
8
6
4
2
0
-2
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5


SDQ Externalising Scale Q-Q Plot
20
15
10
5
0
-5
-10
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5


SDQ Internalising Scale Q-Q Plot
20
15
10
5
0
-5
-10
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

Appendix 14 – Tables for Items Regression Model

SDQ Total Score Item Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.98	0.96	0.85	3.62

SDQ Total Score Item ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	1699.76	14	121.41	9.28	0.006
Residual	78.52	6	13.09		
Total	1778.29	20			

SDQ Total Score Item Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
Constant	79.51	14.30	0.00	5.56	0.001	44.51	114.50
Auditory Processing	-1.13	0.43	-0.71	-2.61	0.040	-2.19	-0.07
Visual Processing	-2.03	0.73	-1.36	-2.76	0.033	-3.82	-0.23
Vestibular Processing	0.69	0.34	0.54	2.05	0.086	-0.13	1.51
Touch Processing	-1.41	0.49	-1.51	-2.88	0.028	-2.62	-0.21
Multisensory Processing	1.72	0.70	1.11	2.45	0.050	0.00	3.44
Oral Sensory Processing	0.05	0.32	0.06	0.16	0.877	-0.73	0.84
Sensory Processing Related to Endurance/Tone	0.24	0.24	0.19	0.99	0.359	-0.35	0.83
Modulation Related to Body Position and Movement	0.22	0.30	0.14	0.75	0.483	-0.51	0.96
Modulation of Movement Affecting Activity Level	1.43	0.56	0.65	2.55	0.044	0.06	2.81
Modulation of Sensory Input Affecting Emotional Responses	-1.66	1.08	-0.67	-1.55	0.173	-4.30	0.97
Modulation of Visual Input Affecting Emotional Responses and Activity Level	3.21	0.97	0.97	3.31	0.016	0.84	5.58
Emotional/Social Response	-0.94	0.20	-1.52	-4.74	0.003	-1.42	-0.45
Behavioural Outcomes of Sensory Processing	1.63	0.72	1.08	2.27	0.063	-0.12	3.39
Items Indicating Thresholds for Response	0.52	0.97	0.14	0.54	0.611	-1.86	2.90

SDQ Emotional Scale Sensory Processing Items Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.89	0.78	0.28	2.41

SDQ Emotional Scale Sensory Processing Items ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	126.82	14	9.06	1.55	0.305
Residual	34.99	6	5.83		
Total	161.81	20			

SDQ Emotional Scale Sensory Processing Items Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
Constant	23.08	9.55	0.00	2.42	0.046	-0.28	46.44
Auditory Processing	-0.45	0.29	-0.93	-1.55	0.172	-1.16	0.26
Visual Processing	0.01	0.49	0.01	0.01	0.990	-1.19	1.20
Vestibular Processing	-0.11	0.22	-0.28	-0.48	0.651	-0.66	0.44
Touch Processing	-0.24	0.33	-0.84	-0.73	0.494	-1.04	0.56
Multisensory Processing	0.46	0.47	0.98	0.97	0.369	-0.69	1.60
Oral Sensory Processing	-0.25	0.21	-0.89	-1.18	0.282	-0.78	0.27
Sensory Processing Related to Endurance/Tone	-0.11	0.16	-0.29	-0.68	0.523	-0.50	0.28
Modulation Related to Body Position and Movement	-0.08	0.20	-0.17	-0.39	0.707	-0.57	0.41
Modulation of Movement Affecting Activity Level	0.27	0.38	0.41	0.72	0.501	-0.65	1.19
Modulation of Sensory Input Affecting Emotional Responses	0.36	0.72	0.48	0.50	0.638	-1.40	2.12
Modulation of Visual Input Affecting Emotional Responses and Activity Level	0.51	0.65	0.51	0.79	0.462	-1.07	2.09
Emotional/Social Response	-0.19	0.13	-1.04	-1.47	0.193	-0.52	0.13
Behavioural Outcomes of Sensory Processing	0.14	0.48	0.31	0.29	0.782	-1.03	1.31
Items Indicating Thresholds for Response	0.86	0.65	0.77	1.33	0.231	-0.72	2.45

SDQ Conduct Scale Sensory Processing Items Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.91	0.84	0.45	1.61

SDQ Conduct Scale Sensory Processing Items ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	79.13	14	5.65	2.18	0.172
Residual	15.54	6	2.59		
Total	94.67	20			

SDQ Conduct Scale Sensory Processing Items Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
Constant	13.26	6.36	0.00	2.09	0.076	-2.30	28.83
Auditory Processing	-0.32	0.19	-0.86	-1.65	0.151	-0.79	0.15
Visual Processing	-0.57	0.33	-1.66	-1.75	0.130	-1.37	0.23
Vestibular Processing	0.17	0.15	0.59	1.15	0.293	-0.19	0.54
Touch Processing	-0.39	0.22	-1.79	-1.78	0.126	-0.92	0.15
Multisensory Processing	0.59	0.31	1.66	1.90	0.107	-0.17	1.36
Oral Sensory Processing	0.05	0.14	0.21	0.32	0.760	-0.30	0.40
Sensory Processing Related to Endurance/Tone	0.12	0.11	0.43	1.14	0.298	-0.14	0.38
Modulation Related to Body Position and Movement	0.14	0.13	0.38	1.03	0.343	-0.19	0.47
Modulation of Movement Affecting Activity Level	0.42	0.25	0.83	1.68	0.144	-0.19	1.03
Modulation of Sensory Input Affecting Emotional Responses	-0.61	0.48	-1.07	-1.28	0.247	-1.79	0.56
Modulation of Visual Input Affecting Emotional Responses and Activity Level	0.88	0.43	1.15	2.03	0.088	-0.18	1.93
Emotional/Social Response	-0.28	0.09	-1.98	-3.20	0.019	-0.50	-0.07
Behavioural Outcomes of Sensory Processing	0.53	0.32	1.53	1.66	0.147	-0.25	1.31
Items Indicating Thresholds for Response	0.17	0.43	0.20	0.39	0.710	-0.89	1.23

SDQ Hyperactivity Scale Sensory Processing Items Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.96	0.92	0.74	1.71

SDQ Hyperactivity Scale Sensory Processing Items ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	208.94	14	14.92	5.08	0.028
Residual	17.63	6	2.94		
Total	226.57	20			

SDQ Hyperactivity Scale Sensory Processing Items Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
Constant	24.82	6.78	0.00	3.66	0.008	8.24	41.41
Auditory Processing	-0.34	0.21	-0.59	-1.64	0.152	-0.84	0.17
Visual Processing	-1.09	0.35	-2.04	-3.13	0.020	-1.94	-0.24
Vestibular Processing	0.53	0.16	1.18	3.36	0.015	0.14	0.92
Touch Processing	-0.71	0.23	-2.11	-3.04	0.023	-1.28	-0.14
Multisensory Processing	0.51	0.33	0.93	1.53	0.176	-0.30	1.33
Oral Sensory Processing	0.27	0.15	0.82	1.81	0.121	-0.10	0.65
Sensory Processing Related to Endurance/Tone	0.32	0.11	0.72	2.79	0.032	0.04	0.60
Modulation Related to Body Position and Movement	0.01	0.14	0.02	0.10	0.927	-0.34	0.36
Modulation of Movement Affecting Activity Level	0.61	0.27	0.78	2.29	0.062	-0.04	1.26
Modulation of Sensory Input Affecting Emotional Responses	-1.34	0.51	-1.52	-2.63	0.039	-2.59	-0.09
Modulation of Visual Input Affecting Emotional Responses and Activity Level	1.56	0.46	1.32	3.39	0.015	0.43	2.68
Emotional/Social Response	-0.24	0.09	-1.08	-2.53	0.045	-0.47	-0.01
Behavioural Outcomes of Sensory Processing	0.80	0.34	1.49	2.35	0.057	-0.03	1.63
Items Indicating Thresholds for Response	-0.40	0.46	-0.30	-0.87	0.416	-1.53	0.72

SDQ Peer Relations Scale Sensory Processing Items Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.95	0.90	0.65	1.67

SDQ Peer Relations Scale Sensory Processing Items ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	144.13	14	10.29	3.67	0.059
Residual	16.82	6	2.80		
Total	160.95	20			

SDQ Peer Relations Scale Sensory Processing Items Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
Constant	18.34	6.62	0.00	2.77	0.028	2.14	34.54
Auditory Processing	-0.03	0.20	-0.06	-0.15	0.887	-0.52	0.46
Visual Processing	-0.37	0.34	-0.83	-1.10	0.313	-1.20	0.46
Vestibular Processing	0.09	0.16	0.24	0.58	0.584	-0.29	0.47
Touch Processing	-0.08	0.23	-0.28	-0.35	0.737	-0.64	0.48
Multisensory Processing	0.16	0.33	0.35	0.49	0.639	-0.64	0.96
Oral Sensory Processing	-0.02	0.15	-0.05	-0.10	0.922	-0.38	0.35
Sensory Processing Related to Endurance/Tone	-0.09	0.11	-0.25	-0.82	0.442	-0.36	0.18
Modulation Related to Body Position and Movement	0.15	0.14	0.33	1.10	0.315	-0.19	0.49
Modulation of Movement Affecting Activity Level	0.13	0.26	0.20	0.52	0.624	-0.50	0.77
Modulation of Sensory Input Affecting Emotional Responses	-0.06	0.50	-0.09	-0.13	0.902	-1.28	1.16
Modulation of Visual Input Affecting Emotional Responses and Activity Level	0.26	0.45	0.27	0.59	0.576	-0.83	1.36
Emotional/Social Response	-0.23	0.09	-1.22	-2.47	0.049	-0.45	0.00
Behavioural Outcomes of Sensory Processing	0.16	0.33	0.36	0.49	0.641	-0.65	0.98
Items Indicating Thresholds for Response	-0.11	0.45	-0.10	-0.24	0.816	-1.21	0.99

SDQ Pro-social Scale Sensory Processing Items Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.96	0.92	0.75	1.37

SDQ Pro-social Scale ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	138.52	14	9.89	5.26	0.025
Residual	11.29	6	1.88		
Total	149.81	20			

SDQ Pro-social Scale Sensory Processing Items Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
Constant	-16.45	5.42	0.00	-3.03	0.019	-29.72	-3.18
Auditory Processing	0.46	0.16	0.99	2.78	0.032	0.06	0.86
Visual Processing	0.84	0.28	1.94	3.02	0.023	0.16	1.52
Vestibular Processing	-0.12	0.13	-0.33	-0.96	0.374	-0.43	0.19
Touch Processing	0.54	0.19	1.98	2.90	0.027	0.08	1.00
Multisensory Processing	-1.05	0.27	-2.35	-3.96	0.007	-1.71	-0.40
Oral Sensory Processing	0.00	0.12	-0.02	-0.04	0.971	-0.30	0.29
Sensory Processing Related to Endurance/Tone	0.11	0.09	0.29	1.16	0.290	-0.12	0.33
Modulation Related to Body Position and Movement	-0.11	0.11	-0.25	-0.98	0.366	-0.39	0.17
Modulation of Movement Affecting Activity Level	-0.88	0.21	-1.39	-4.14	0.006	-1.40	-0.36
Modulation of Sensory Input Affecting Emotional Responses	0.58	0.41	0.81	1.42	0.206	-0.42	1.58
Modulation of Visual Input Affecting Emotional Responses and Activity Level	-0.91	0.37	-0.95	-2.48	0.048	-1.81	-0.01
Emotional/Social Response	0.34	0.07	1.89	4.52	0.004	0.16	0.52
Behavioural Outcomes of Sensory Processing	-0.84	0.27	-1.92	-3.08	0.022	-1.51	-0.17
Items Indicating Thresholds for Response	-0.05	0.37	-0.05	-0.13	0.897	-0.95	0.85

SDQ Externalising Scale Sensory Processing Items Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.94	0.89	0.63	3.15

SDQ Externalising Scale Sensory Processing Items ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	479.72	14	34.27	3.45	0.068
Residual	59.52	6	9.92		
Total	539.24	20			

SDQ Externalising Scale Sensory Processing Items Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
Constant	38.09	12.45	0.00	3.06	0.018	7.62	68.55
Auditory Processing	-0.65	0.38	-0.74	-1.73	0.134	-1.58	0.27
Visual Processing	-1.66	0.64	-2.02	-2.60	0.041	-3.22	-0.10
Vestibular Processing	0.71	0.29	1.01	2.42	0.052	-0.01	1.42
Touch Processing	-1.09	0.43	-2.12	-2.56	0.043	-2.14	-0.05
Multisensory Processing	1.10	0.61	1.30	1.80	0.121	-0.39	2.60
Oral Sensory Processing	0.32	0.28	0.62	1.15	0.295	-0.36	1.00
Sensory Processing Related to Endurance/Tone	0.44	0.21	0.64	2.10	0.081	-0.07	0.95
Modulation Related to Body Position and Movement	0.15	0.26	0.18	0.58	0.585	-0.49	0.79
Modulation of Movement Affecting Activity Level	1.03	0.49	0.85	2.10	0.080	-0.17	2.23
Modulation of Sensory Input Affecting Emotional Responses	-1.96	0.94	-1.43	-2.09	0.082	-4.25	0.34
Modulation of Visual Input Affecting Emotional Responses and Activity Level	2.43	0.84	1.33	2.88	0.028	0.37	4.50
Emotional/Social Response	-0.52	0.17	-1.53	-3.01	0.024	-0.94	-0.10
Behavioural Outcomes of Sensory Processing	1.33	0.63	1.60	2.13	0.077	-0.20	2.86
Items Indicating Thresholds for Response	-0.23	0.85	-0.11	-0.28	0.791	-2.31	1.84

SDQ Internalising Scale Sensory Processing Items Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.93	0.86	0.52	3.72

SDQ Internalising Scale Sensory Processing Items ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	494.11	14	35.29	2.55	0.128
Residual	83.13	6	13.85		
Total	577.24	20			

SDQ Internalising Scale Sensory Processing Items Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
Constant	41.42	14.71	0.00	2.81	0.026	5.41	77.42
Auditory Processing	-0.48	0.45	-0.53	-1.07	0.325	-1.57	0.61
Visual Processing	-0.37	0.75	-0.43	-0.49	0.644	-2.21	1.48
Vestibular Processing	-0.02	0.35	-0.02	-0.05	0.962	-0.86	0.83
Touch Processing	-0.32	0.51	-0.60	-0.63	0.551	-1.55	0.92
Multisensory Processing	0.62	0.72	0.70	0.85	0.427	-1.15	2.39
Oral Sensory Processing	-0.27	0.33	-0.50	-0.81	0.447	-1.08	0.54
Sensory Processing Related to Endurance/Tone	-0.20	0.25	-0.28	-0.81	0.449	-0.81	0.40
Modulation Related to Body Position and Movement	0.07	0.31	0.08	0.24	0.820	-0.68	0.83
Modulation of Movement Affecting Activity Level	0.40	0.58	0.32	0.70	0.512	-1.01	1.82
Modulation of Sensory Input Affecting Emotional Responses	0.29	1.11	0.21	0.26	0.801	-2.42	3.00
Modulation of Visual Input Affecting Emotional Responses and Activity Level	0.77	1.00	0.41	0.78	0.467	-1.67	3.21
Emotional/Social Response	-0.42	0.20	-1.19	-2.06	0.085	-0.92	0.08
Behavioural Outcomes of Sensory Processing	0.30	0.74	0.35	0.41	0.697	-1.51	2.11
Items Indicating Thresholds for Response	0.76	1.00	0.36	0.75	0.479	-1.69	3.20

Appendix 15 – Tables for Factor Regression Models

SDQ Total Scale Factor Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.91	0.83	0.70	5.2

SDQ Total Scale Factor ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	1481.29	9	164.59	6.10	0.003
Residual	297	11	27		
Total	1778.29	20			

SDQ Total Scale Factor Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
(Constant)	42.94	15.61	0.00	2.75	0.019	8.17	77.71
Factor 1: Sensory Seeking	-0.10	0.21	-0.16	-0.50	0.627	-0.56	0.36
Factor 2: Emotional Reactivity	-0.31	0.21	-0.54	-1.43	0.182	-0.78	0.17
Factor 3: Low Endurance/Tone	0.04	0.28	0.03	0.13	0.897	-0.59	0.67
Factor 4: Oral Sensitivity	-0.10	0.25	-0.10	-0.41	0.690	-0.67	0.46
Factor 5: Inattention/Distractibility	-0.40	0.38	-0.27	-1.05	0.318	-1.26	0.45
Factor 6: Poor Registration	0.41	0.66	0.19	0.62	0.552	-1.07	1.88
Factor 7: Sensory Sensitivity	0.02	0.45	0.01	0.04	0.965	-0.99	1.03
Factor 8: Sedentary	-0.26	0.49	-0.13	-0.53	0.609	-1.36	0.84
Factor 9: Fine Motor/Perceptual	-0.54	0.56	-0.22	-0.96	0.359	-1.79	0.71

SDQ Emotional Scale Factor Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.85	0.72	0.46	1.94

SDQ Emotional Scale Factor ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	95.39	9	10.6	2.82	0.061
Residual	37.61	11	3.76		
Total	133	20			

SDQ Emotional Scale Factor Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
(Constant)	10.82	5.91	0.00	1.83	0.094	-2.34	23.99
Factor 1: Sensory Seeking	0.00	0.08	-0.01	-0.04	0.971	-0.18	0.17
Factor 2: Emotional Reactivity	-0.06	0.08	-0.34	-0.73	0.484	-0.24	0.12
Factor 3: Low Endurance/Tone	-0.01	0.11	-0.02	-0.06	0.953	-0.25	0.23
Factor 4: Oral Sensitivity	-0.09	0.10	-0.31	-0.99	0.346	-0.31	0.12
Factor 5: Inattention/Distractibility	-0.12	0.15	-0.27	-0.85	0.416	-0.45	0.20
Factor 6: Poor Registration	0.24	0.25	0.36	0.95	0.364	-0.32	0.80
Factor 7: Sensory Sensitivity	-0.13	0.17	-0.19	-0.74	0.479	-0.51	0.26
Factor 8: Sedentary	-0.17	0.19	-0.26	-0.90	0.390	-0.58	0.25
Factor 9: Fine Motor/Perceptual	-0.18	0.21	-0.24	-0.86	0.411	-0.65	0.29

SDQ Conduct Scale Factor Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.76	0.57	0.19	1.75

SDQ Conduct Scale Factor ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	41.13	9	4.57	1.49	0.271
Residual	30.67	11	3.07		
Total	71.8	20			

SDQ Conduct Scale Factor Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
(Constant)	1.36	5.34	0.00	0.25	0.804	-10.53	13.25
Factor 1: Sensory Seeking	0.00	0.07	0.01	0.02	0.983	-0.16	0.16
Factor 2: Emotional Reactivity	-0.13	0.07	-1.01	-1.77	0.107	-0.29	0.03
Factor 3: Low Endurance/Tone	0.06	0.10	0.23	0.60	0.564	-0.16	0.27
Factor 4: Oral Sensitivity	0.04	0.09	0.20	0.51	0.618	-0.15	0.24
Factor 5: Inattention/Distractibility	-0.06	0.13	-0.17	-0.43	0.678	-0.35	0.24
Factor 6: Poor Registration	0.17	0.23	0.34	0.75	0.473	-0.34	0.67
Factor 7: Sensory Sensitivity	0.10	0.16	0.20	0.64	0.538	-0.25	0.44
Factor 8: Sedentary	-0.05	0.17	-0.12	-0.32	0.755	-0.43	0.32
Factor 9: Fine Motor/Perceptual	-0.10	0.19	-0.18	-0.53	0.607	-0.53	0.33

SDQ Hyperactivity Scale Factor Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.85	0.73	0.48	2.35

SDQ Hyperactivity Scale Factor ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	146.63	9	16.29	2.95	0.053
Residual	55.17	11	5.52		
Total	201.8	20			

SDQ Hyperactivity Scale Factor Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
(Constant)	15.25	7.16	0.00	2.13	0.057	-0.70	31.19
Factor 1: Sensory Seeking	-0.10	0.09	-0.42	-1.10	0.297	-0.32	0.11
Factor 2: Emotional Reactivity	-0.04	0.10	-0.17	-0.38	0.714	-0.26	0.18
Factor 3: Low Endurance/Tone	0.05	0.13	0.13	0.42	0.685	-0.24	0.34
Factor 4: Oral Sensitivity	-0.01	0.12	-0.03	-0.11	0.914	-0.27	0.25
Factor 5: Inattention/Distractibility	-0.21	0.18	-0.37	-1.20	0.259	-0.60	0.18
Factor 6: Poor Registration	0.05	0.30	0.06	0.15	0.880	-0.63	0.72
Factor 7: Sensory Sensitivity	-0.07	0.21	-0.09	-0.35	0.732	-0.54	0.39
Factor 8: Sedentary	0.14	0.23	0.19	0.64	0.536	-0.36	0.65
Factor 9: Fine Motor/Perceptual	-0.13	0.26	-0.14	-0.51	0.622	-0.70	0.44

SDQ Peer Relations Scale Factor Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.89	0.79	0.6	1.75

SDQ Peer Relations Scale Factor ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	113.9	9	12.66	4.13	0.019
Residual	30.65	11	3.07		
Total	144.55	20			

SDQ Peer Relations Scale Factor Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
(Constant)	15.51	5.33	0.00	2.91	0.014	3.63	27.40
Factor 1: Sensory Seeking	0.00	0.07	0.01	0.03	0.979	-0.16	0.16
Factor 2: Emotional Reactivity	-0.08	0.07	-0.45	-1.11	0.292	-0.24	0.08
Factor 3: Low Endurance/Tone	-0.07	0.10	-0.19	-0.70	0.499	-0.28	0.15
Factor 4: Oral Sensitivity	-0.04	0.09	-0.13	-0.47	0.647	-0.23	0.15
Factor 5: Inattention/Distractibility	-0.01	0.13	-0.03	-0.10	0.923	-0.31	0.28
Factor 6: Poor Registration	-0.05	0.23	-0.07	-0.21	0.841	-0.55	0.46
Factor 7: Sensory Sensitivity	0.12	0.16	0.17	0.78	0.454	-0.22	0.47
Factor 8: Sedentary	-0.18	0.17	-0.28	-1.09	0.303	-0.56	0.19
Factor 9: Fine Motor/Perceptual	-0.12	0.19	-0.16	-0.65	0.532	-0.55	0.30

SDQ Pro-social Scale Factor Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.69	0.48	0	2.66

SDQ Pro-social Scale ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	64.2	9	7.13	1.01	0.491
Residual	70.75	11	7.08		
Total	134.95	20			

SDQ Pro-social Scale Factor Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
(Constant)	4.82	8.10	0.00	0.59	0.564	-13.24	22.87
Factor 1: Sensory Seeking	-0.09	0.11	-0.44	-0.84	0.423	-0.33	0.15
Factor 2: Emotional Reactivity	0.11	0.11	0.65	1.03	0.328	-0.13	0.36
Factor 3: Low Endurance/Tone	0.14	0.15	0.42	0.97	0.353	-0.18	0.47
Factor 4: Oral Sensitivity	-0.08	0.13	-0.25	-0.59	0.568	-0.37	0.22
Factor 5: Inattention/Distractibility	0.23	0.20	0.50	1.16	0.274	-0.21	0.68
Factor 6: Poor Registration	-0.15	0.34	-0.22	-0.44	0.671	-0.92	0.62
Factor 7: Sensory Sensitivity	0.01	0.24	0.02	0.06	0.956	-0.51	0.54
Factor 8: Sedentary	-0.11	0.26	-0.17	-0.43	0.675	-0.68	0.46
Factor 9: Fine Motor/Perceptual	0.00	0.29	0.00	0.01	0.992	-0.65	0.65

SDQ Externalising Scale Factor Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.82	0.67	0.38	3.8

SDQ Externalising Scale Factor ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	299.57	9	33.29	2.3	0.105
Residual	144.43	11	14.44		
Total	444	20			

SDQ Externalising Scale Factor Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
(Constant)	16.61	11.58	0.00	1.43	0.179	-9.19	42.41
Factor 1: Sensory Seeking	-0.10	0.15	-0.28	-0.67	0.518	-0.44	0.24
Factor 2: Emotional Reactivity	-0.17	0.16	-0.52	-1.05	0.319	-0.52	0.19
Factor 3: Low Endurance/Tone	0.11	0.21	0.18	0.53	0.606	-0.36	0.58
Factor 4: Oral Sensitivity	0.03	0.19	0.06	0.17	0.870	-0.39	0.45
Factor 5: Inattention/Distractibility	-0.27	0.29	-0.32	-0.94	0.371	-0.90	0.37
Factor 6: Poor Registration	0.22	0.49	0.18	0.44	0.670	-0.88	1.31
Factor 7: Sensory Sensitivity	0.03	0.34	0.02	0.08	0.941	-0.72	0.78
Factor 8: Sedentary	0.09	0.37	0.08	0.25	0.809	-0.72	0.90
Factor 9: Fine Motor/Perceptual	-0.23	0.42	-0.17	-0.56	0.588	-1.16	0.69

SDQ Internalising Scale Factor Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.89	0.78	0.59	3.24

SDQ Internalising Scale Factor ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	383.34	9	42.59	4.05	0.020
Residual	105.21	11	10.52		
Total	488.55	20			

SDQ Internalising Scale Factor Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
(Constant)	26.34	9.88	0.00	2.66	0.022	4.31	48.36
Factor 1: Sensory Seeking	0.00	0.13	0.00	-0.01	0.994	-0.29	0.29
Factor 2: Emotional Reactivity	-0.14	0.14	-0.42	-1.03	0.325	-0.44	0.16
Factor 3: Low Endurance/Tone	-0.07	0.18	-0.11	-0.42	0.687	-0.47	0.33
Factor 4: Oral Sensitivity	-0.14	0.16	-0.23	-0.85	0.417	-0.49	0.22
Factor 5: Inattention/Distractibility	-0.14	0.24	-0.15	-0.56	0.587	-0.68	0.41
Factor 6: Poor Registration	0.19	0.42	0.15	0.46	0.657	-0.74	1.13
Factor 7: Sensory Sensitivity	-0.01	0.29	0.00	-0.02	0.985	-0.65	0.63
Factor 8: Sedentary	-0.35	0.31	-0.29	-1.12	0.288	-1.04	0.34
Factor 9: Fine Motor/Perceptual	-0.31	0.35	-0.21	-0.86	0.409	-1.10	0.48

Appendix 16 – Tables for Quadrant Regression Models

SDQ Total Score Quadrant Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.85	0.72	0.65	5.59

SDQ Total Score Quadrant ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	1277.78	4	319.45	10.21	<0.001
Residual	500.50	16	31.28		
Total	1778.29	20			

SDQ Total Score Quadrant Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
Constant	70.84	9.76	0.00	7.26	<0.001	50.16	91.52
Quadrant 1: Low Registration	-0.01	0.17	-0.01	-0.04	0.967	-0.37	0.35
Quadrant 2: Sensation Seeking	-0.17	0.08	-0.35	-2.10	0.052	-0.34	0.00
Quadrant 3: Sensory Sensitivity	-0.23	0.20	-0.28	-1.14	0.273	-0.66	0.20
Quadrant 4: Sensation Avoidant	-0.20	0.17	-0.32	-1.15	0.268	-0.56	0.17

SDQ Emotional Scale Quadrant Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.83	0.69	0.61	1.78

SDQ Emotional Scale Quadrant ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	111.15	4	27.79	8.78	0.001
Residual	50.66	16	3.17		
Total	161.81	20			

SDQ Emotional Scale Quadrant Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
Constant	20.21	3.10	0.00	6.51	<0.001	13.63	26.79
Quadrant 1: Low Registration	-0.02	0.05	-0.08	-0.41	0.686	-0.14	0.09
Quadrant 2: Sensation Seeking	0.00	0.03	0.00	0.00	0.999	-0.05	0.05
Quadrant 3: Sensory Sensitivity	-0.15	0.06	-0.61	-2.31	0.035	-0.28	-0.01
Quadrant 4: Sensation Avoidant	-0.04	0.05	-0.20	-0.69	0.502	-0.15	0.08

SDQ Conduct Scale Quadrant Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.68	0.46	0.33	1.78

SDQ Conduct Scale Quadrant ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	43.74	4	10.94	3.44	0.033
Residual	50.93	16	3.18		
Total	94.67	20			

SDQ Conduct Scale Quadrant Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
Constant	10.72	3.11	0.00	3.44	0.003	4.12	17.31
Quadrant 1: Low Registration	0.09	0.05	0.40	1.62	0.126	-0.03	0.20
Quadrant 2: Sensation Seeking	-0.04	0.03	-0.35	-1.48	0.159	-0.09	0.02
Quadrant 3: Sensory Sensitivity	0.03	0.06	0.18	0.51	0.617	-0.10	0.17
Quadrant 4: Sensation Avoidant	-0.11	0.05	-0.78	-1.98	0.065	-0.23	0.01

SDQ Hyperactivity Scale Quadrant Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.81	0.65	0.56	2.22

SDQ Hyperactivity Scale Quadrant ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	147.62	4	36.91	7.48	0.001
Residual	78.95	16	4.93		
Total	226.57	20			

SDQ Hyperactivity Scale Quadrant Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
Constant	18.93	3.87	0.00	4.89	<0.001	10.72	27.14
Quadrant 1: Low Registration	0.01	0.07	0.02	0.08	0.937	-0.14	0.15
Quadrant 2: Sensation Seeking	-0.13	0.03	-0.74	-3.94	0.001	-0.20	-0.06
Quadrant 3: Sensory Sensitivity	-0.08	0.08	-0.29	-1.04	0.314	-0.25	0.09
Quadrant 4: Sensation Avoidant	0.04	0.07	0.19	0.60	0.559	-0.10	0.19

SDQ Peer Relationships Scale Quadrant Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.83	0.68	0.61	1.78

SDQ Peer Relationships Scale Quadrant ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	110.10	4	27.52	8.66	0.001
Residual	50.86	16	3.18		
Total	160.95	20			

SDQ Peer Relationships Scale Quadrant Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
Constant	20.98	3.11	0.00	6.75	<0.001	14.39	27.57
Quadrant 1: Low Registration	-0.08	0.05	-0.27	-1.44	0.170	-0.19	0.04
Quadrant 2: Sensation Seeking	0.00	0.03	-0.03	-0.19	0.851	-0.06	0.05
Quadrant 3: Sensory Sensitivity	-0.03	0.06	-0.12	-0.47	0.643	-0.17	0.11
Quadrant 4: Sensation Avoidant	-0.09	0.05	-0.50	-1.67	0.115	-0.21	0.02

SDQ Pro-social Scale Quadrant Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.56	0.32	0.15	2.53

SDQ Pro-social Scale Quadrant ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	47.38	4	11.84	1.85	0.169
Residual	102.43	16	6.40		
Total	149.81	20			

SDQ Pro-social Scale Quadrant Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
Constant	-3.02	4.41	0.00	-0.68	0.503	-12.37	6.34
Quadrant 1: Low Registration	0.12	0.08	0.44	1.56	0.139	-0.04	0.28
Quadrant 2: Sensation Seeking	-0.02	0.04	-0.15	-0.55	0.590	-0.10	0.06
Quadrant 3: Sensory Sensitivity	-0.02	0.09	-0.07	-0.19	0.854	-0.21	0.18
Quadrant 4: Sensation Avoidant	0.05	0.08	0.30	0.69	0.499	-0.11	0.22

SDQ Externalising Scale Quadrant Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.76	0.57	0.47	3.79

SDQ Externalising Scale Quadrant ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	309.74	4	77.44	5.40	0.006
Residual	229.49	16	14.34		
Total	539.24	20			

SDQ Externalising Scale Quadrant Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
Constant	29.65	6.61	<0.001	4.49	<0.001	15.64	43.65
Quadrant 1: Low Registration	0.09	0.11	0.18	0.81	0.431	-0.15	0.34
Quadrant 2: Sensation Seeking	-0.17	0.06	-0.63	-3.00	0.008	-0.28	-0.05
Quadrant 3: Sensory Sensitivity	-0.05	0.14	-0.11	-0.37	0.717	-0.34	0.24
Quadrant 4: Sensation Avoidant	-0.07	0.12	-0.20	-0.59	0.567	-0.32	0.18

SDQ Internalising Scale Quadrant Regression Model Summary

R	R^2	Adj R^2	Std. Err of Est
0.86	0.74	0.67	3.09

SDQ Internalising Scale Quadrant ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	424.3	4	106.07	11.10	<0.001
Residual	152.94	16	9.56		
Total	577.24	20			

SDQ Internalising Scale Quadrant Coefficients

	Unstd Coeff		Std Coeff			95% CI for B	
	B	Std. Err	Beta	t	Sig.	Low	Upper
Constant	41.19	5.39	0.00	7.64	<0.001	29.76	52.62
Quadrant 1: Low Registration	-0.10	0.09	-0.19	-1.07	0.302	-0.30	0.10
Quadrant 2: Sensation Seeking	<0.001	0.04	-0.02	-0.11	0.913	-0.10	0.09
Quadrant 3: Sensory Sensitivity	-0.18	0.11	-0.39	-1.60	0.129	-0.42	0.06
Quadrant 4: Sensation Avoidant	-0.13	0.10	-0.37	-1.36	0.193	-0.33	0.07

Appendix 17 – Example of a Clinical Interpretation of the SCPQ

SENSORY PROFILE
Winnie Dunn,
Ph.D., OTR, FAOTA

Summary and Interpretive Report

Child's Name: Gerald Sample
Date of Birth: 7/31/1996
Age: 10 years 0 months
Service Provider: Dr. R. Baklery

Completed by: Lee Golde

Daily Life Concern: None

Gender: Male
Administration Date: 8/15/2006

Discipline: Occupational Therapist

Relationship to Child: Mother

The Sensory Profile was administered as part of a comprehensive assessment to determine whether aspects of sensory processing might be contributing to performance challenges in the daily life of Gerald Sample.

The Sensory Profile is a measure of children's responses to sensory events in daily life. The caregiver completes the Sensory Profile by assessing the frequency of a child's responses to certain sensory processing, modulation, and behavioral/emotional events as described in 125 items. We know from research that the Sensory Profile can help identify a child's sensory processing patterns; the results can then be used to consider how these patterns might be contributing to or creating barriers to performance in daily life.

The Sensory Profile was given as a part of a total assessment that included interviews, observations, and other tests to reveal the possible contribution of sensory processing patterns to Gerald's challenges. Lee Golde, Gerald's mother, reports the following concerns about Gerald: None

Summary of Scores

The following paragraphs describe Gerald's performance on the Sensory Profile. Please also refer to the Summary Score report for a visual summary of his scores.

Sensory Processing

Gerald has Probable Difference scores in the following section:

- Multisensory Processing

It is possible that these areas are a challenge for Gerald. He may find it difficult to meaningfully use this type of sensory information. The team will need to conduct additional observations to determine the extent to which these areas impact Gerald's performance challenges.

Gerald has difficulty in the following sections:

- Auditory Processing
- Visual Processing
- Vestibular Processing
- Touch Processing
- Multisensory Processing
- Oral Sensory Processing

These areas are most likely to provide challenges for Gerald. When children have difficulty in a sensory system, it means that this form of sensory input is confusing, upsetting, or not meaningful to the child. In any case, difficulty with sensory input can interfere with Gerald's ability to complete important activities as successfully as other children do. The team will need to conduct additional observations to determine the contribution of these areas to his performance challenges.

Modulation

Gerald obtained scores that indicate typical ability to modulate sensory experiences in daily life. When children have good modulation, this means that they can organize input to create an appropriate adaptive response such as responding to the teacher. Gerald has this ability in one modulation section. He received scores in the typical performance range for the following section:

- Modulation of Movement Affecting Activity Level

Gerald obtained scores that indicate a range of abilities to modulate sensory experiences in daily life.

He has difficulty with:

- Sensory Processing Related to Endurance/Tone
- Modulation Related to Body Position and Movement
- Modulation of Sensory Input Affecting Emotional Responses
- Modulation of Visual Input Affecting Emotional Responses and Activity Level

This means the child will have problems in the following areas:

- Sitting for long periods, remaining alert and maintaining participation with peers.
- Anticipating how to move around safely, without clumsiness, incoordination, or frequent injuries.
- Responding appropriately to social and environmental cues, becoming inflexible or upset by situations more easily than others.
- Understanding the meaning and usefulness of visual information resulting in inappropriate responses.

Behavioral and Emotional Response

The following sections were in the Definite Difference – More than Others and/or Definite Difference Less than Others sections:

- Difficulty with Emotional/Social Responses indicates that Gerald becomes frustrated or upset easily. These responses can sometimes be related to confusing information from the sensory systems. In some cases, Gerald's nervous system is not interpreting the input in a meaningful way, leading to his sense of disruption with what is going around him.
- Difficulty with Behavioral Outcomes of Sensory Processing indicates that Gerald may have difficulty completing tasks or may produce poor quality work. When sensory processing is also difficult for him, a poor score here suggests a relationship between performance demands and ability or efficiency in performing tasks.
- Difficulty with Items Indicating Thresholds for Response indicates that Gerald is having difficulty identifying relevant stimuli. That is, he may need support in order to notice the most important stimuli and react appropriately to those stimuli.

Quadrant Summary

Gerald obtained scores in the Definite Difference – More than Others, and/or Definite Difference – Less Than Others ranges in these quadrants:

- Registration
- Seeking
- Sensitivity
- Avoiding

Children with a Registration pattern tend to miss or take longer to respond to stimuli that others notice. In general, they may have trouble reacting to rapidly presented or low-intensity stimuli. These children may appear withdrawn, uninterested, have low energy levels and act as if they are overly tired all the time.

When children have a "more than others" score in the Registration pattern, this means they notice things less than others. They may not be bothered by things that bother others, but they also may not respond when you call them and have a harder time getting tasks completed in a timely manner.

Children with a Seeking pattern are active and continuously engaged in their environments. These children add sensory input to every experience in daily life. They may appear excitable or seem to lack consideration for safety while playing.

When children have a "more than others" score in the Seeking pattern, this means that they enjoy sensory experiences and seek sensory input. Their interest in sensory events might also lead to difficulties with task completion because they may get distracted with new sensory experiences and lose track of daily life tasks.

Children with a Sensitivity pattern have a high ability to notice what is going on in their environment. They tend to be distractible and may display hyperactivity. They have a pattern of directing their attention to the latest stimulus that presents itself, which draws them away from whatever they are trying to accomplish.

When children have a "more than others" score in the Sensitivity pattern, this means that they notice things more than others, picking up on more details in life. They can be bothered by things that others may not even notice. However, noticing more can also mean these children get interrupted from getting tasks completed in a timely manner.

Children with an Avoiding pattern cope with stimuli by keeping it at bay, either by withdrawing from the stimuli or by engaging in an emotional outburst that enables them to get out of the threatening situation.

When children have a "more than others" score in the Avoiding pattern, this means that they notice and are bothered by things much more than others. They may enjoy being alone or in very quiet places. When environments are too challenging, these children may withdraw and therefore not get activities completed in daily life.

Interpretation of Scores

Whenever possible, the team needs to use Gerald's areas of strength to support his performance. His strengths lie in the areas of:

- Modulation of Movement Affecting Activity Level

Gerald is having difficulty with other ways of processing sensory information and these are likely to be interfering with activities of daily life. He is having difficulty with

- Auditory Processing
- Vestibular Processing
- Touch Processing
- Multisensory Processing
- Oral Sensory Processing
- Sensory Processing Related to Endurance/Tone
- Modulation of Sensory Input Affecting Emotional Responses
- Modulation of Visual Input Affecting Emotional Responses and Activity Level
- Emotional/Social Responses
- Behavioral Outcomes of Sensory Processing
- Items Indicating Threshold for Response
- Registration
- Seeking
- Sensitivity
- Avoiding

Quadrant Interpretation

Children with a "more than others" score in the Registration pattern can profit from more intensity in sensory experiences during daily life. With more intensity of sensory input, these children can continue to pay and maintain attention to the activities of their daily lives.

Children with a "more than others" score in the Seeking pattern can profit from more intensity in experiences as part of daily life so they do not have to stop engaging in daily activities to get the extra sensory input they desire. With more intensity of sensory input, these children can continue to pay attention and stay with an activity for a longer period of time before moving on to another activity.

Children with a "more than others" score in the Sensitivity pattern can profit from more structured patterns of sensory experiences during daily life. With more structure of sensory input, these children can continue to pay attention and stay with an activity for a longer period of time before moving on to another activity.

Children with a "more than others" score in the Avoiding pattern will be better able to participate in everyday life when there is less sensory input available in the environment. When the environment is "quiet," these children can continue to pay attention and stay with an activity for a longer period of time before moving on to another activity.

Other assessments, interviews, and observations should augment the information obtained from Sensory Profile results to identify Gerald's sensory processing features. Dr. R. Baklery will provide input to Gerald's teachers and caregivers to construct additional plans to support

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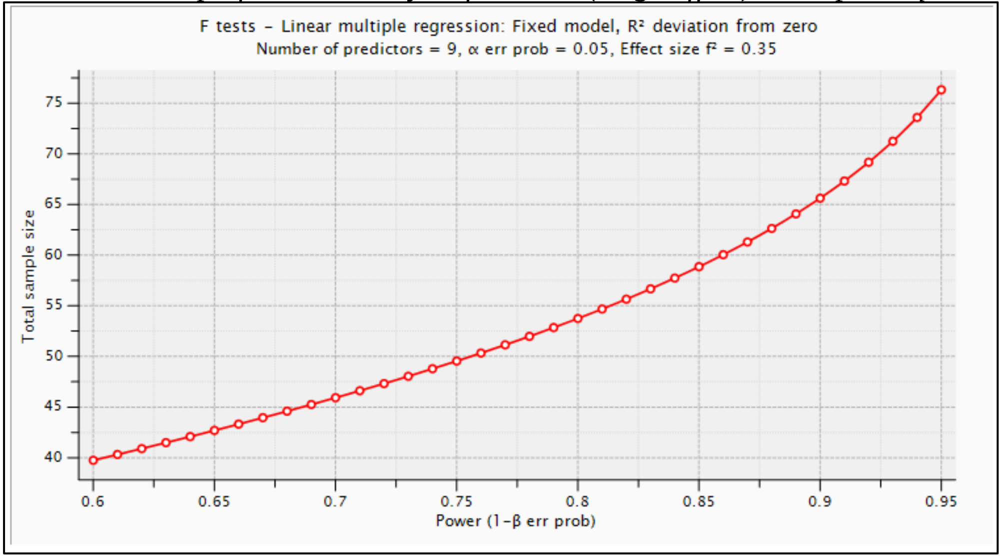
Dr. R. Baklery
Occupational Therapist

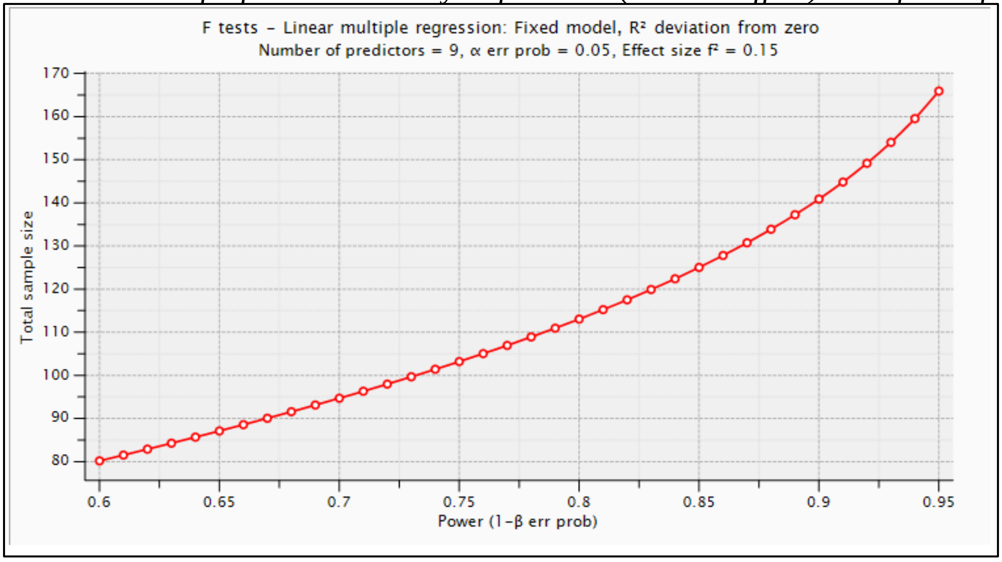
Appendix 18 – A Prior Power Plots

Item Analysis

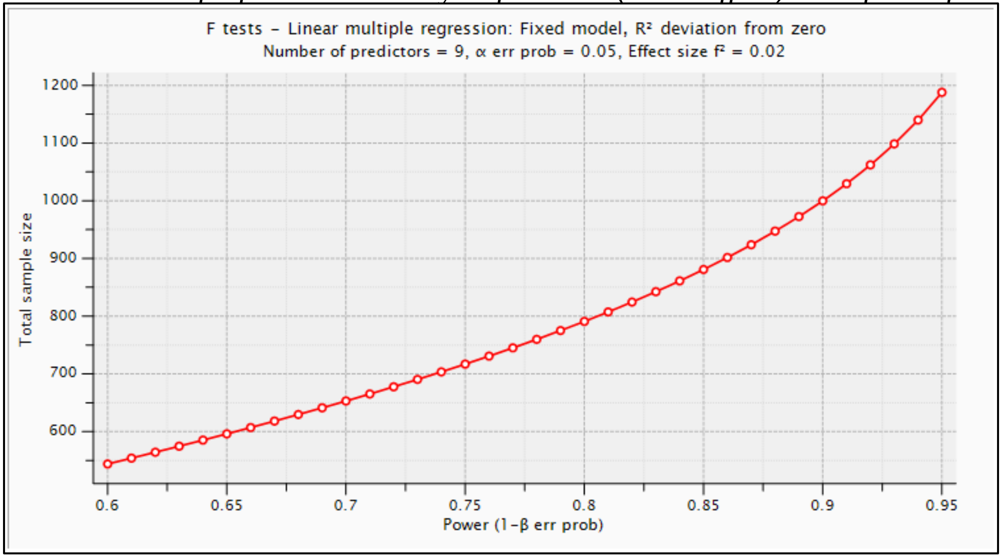
*G*Power Graph for Item Analysis f^2 = 0.35 (large effect) – sample required n = 77*



*G*Power Graph for Factor Analysis f^2 = 0.15 (medium effect) - sample required n = 166*

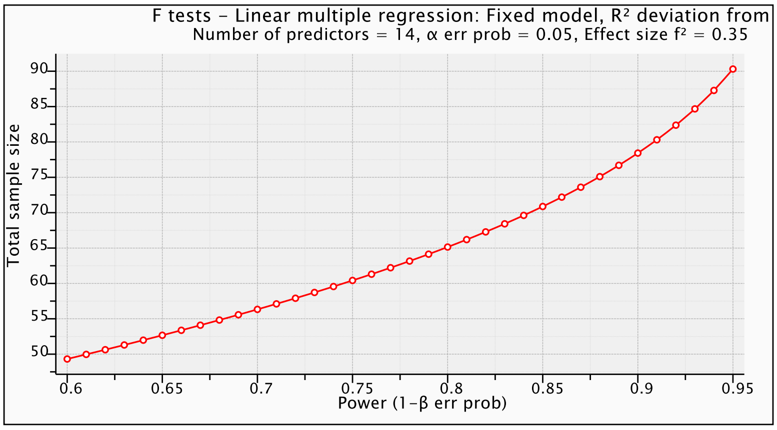


*G*Power Graph for Factor Analysis f^2 = 0.02 (small effect) - sample required n = 1188*

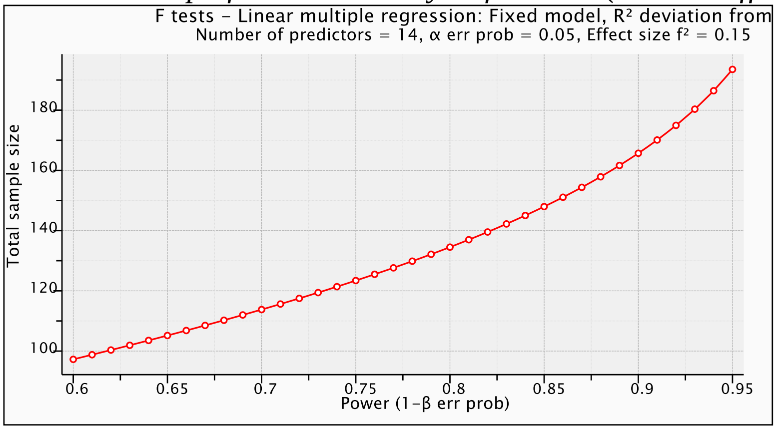


Factor Analysis

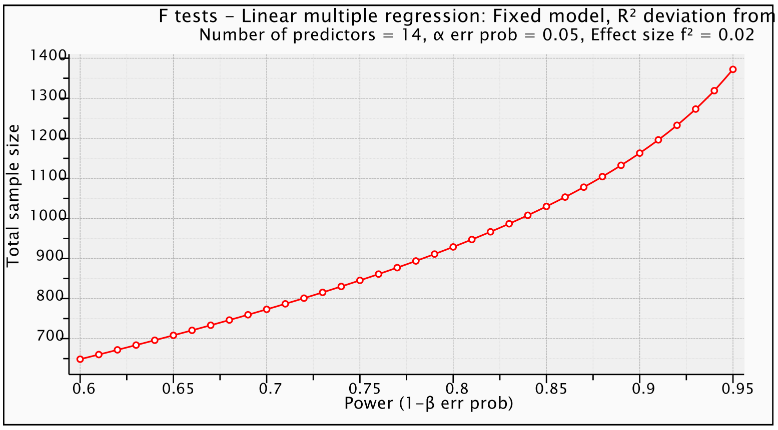
*G*Power Graph for Factor Analysis f^2 = 0.35 (large effect) – sample required n = 91*



*G*Power Graph for Factor Analysis f^2 = 0.15 (medium effect) - sample required n = 194*

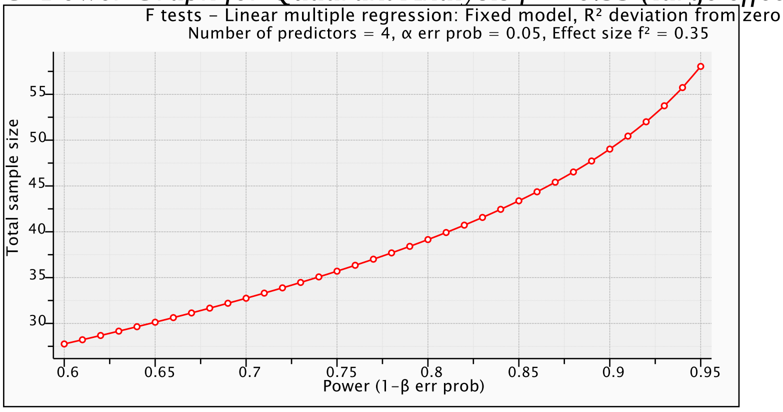


*G*Power Graph for Factor Analysis f^2 = 0.02 (small effect) - sample required n = 1373*

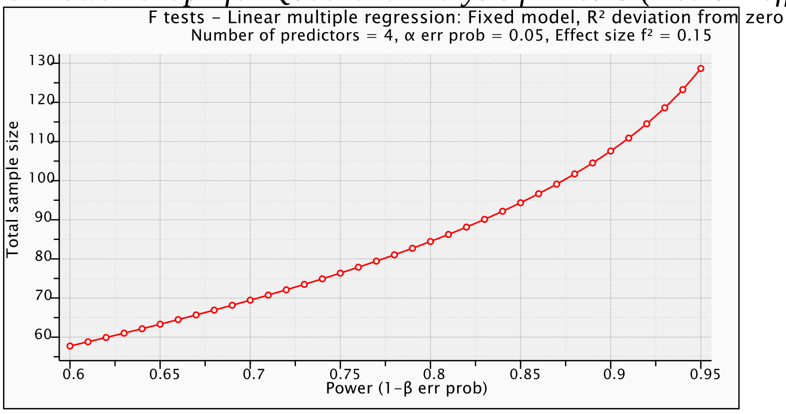


Quadrant Analysis

*G*Power Graph for Quadrant Analysis f^2 = 0.35 (large effect) – sample required n = 59*



*G*Power Graph for Quadrant Analysis f^2 = 0.15 (medium effect) - sample required n = 129*



*G*Power Graph for Quadrant Analysis f^2 = 0.02 (small effect) - sample required n = 934*