WHAT IMPACT DO IRLLEN SPECTRAL FILTERS HAVE ON THE SENSORY PROFILE OF STUDENTS WHO HAVE AUTISM SPECTRUM DISORDERS? A PILOT STUDY.

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Keywords

Autism Spectrum Disorders, Asperger’s Syndrome, High Functioning Autism, Sensory Processing Disorder, student, education, literacy, engagement, academic achievement, Irlen Syndrome, Meares Irlen Syndrome/Visual Stress, interventions, AASP, Adolescent/Adult Sensory Profile, sensory modulation.
Abstract

Background/Aim: The aim of this study is to investigate what impact Irlen Spectral Filters have on the sensory profile of students who have Autism Spectrum Disorders (ASD). The intention was to add to the understanding of the sensory difficulties experienced by these students and the impact these difficulties have on student learning. Irlen Spectral Filters are precision tinted (coloured) ophthalmic lenses, or contacts lenses, that may be used to relieve symptoms related to atypical visual sensory processing.

Method: Six students who identified as having Autism Spectrum Disorder and who wore Irlen Spectral Filters volunteered to participate in the study. The ages of the students ranged from 16 years of age to 51 years of age. The participants completed the Autism Spectrum Quotient (AQ) questionnaire and two Adolescent/Adult Sensory Profile (AASP) questionnaires. Each participant was asked to complete one AASP questionnaire to reflect their sensory experiences when they do not wear their Irlen Spectral Filters, and the other AASP questionnaire to reflect their sensory experiences when they do wear Irlen Spectral Filters.

Only three participants who returned the survey met the inclusion criteria. The participant’s sensory experiences, when they do not and when they do wear their Irlen Spectral Filters were measured using the Adolescent/Adult Sensory Profile (AASP) questionnaire. Each of the participants AASP scores and their responses to each of the AASP sensory statements were compared.

Results: When comparing the two AASP scores of each participant, it was noted that the participants’ scores in each sensory quadrant on the AASP varied between the two conditions, when they do not wear their Irlen Spectral Filters, and when they do wear their Irlen Spectral Filters. Two of the three participants indicated a reduction in sensory scores in every AASP sensory quadrant when they wear their Irlen Spectral Filters. The other participant indicated a reduction in scores in three AASP sensory quadrants, and an increase in the fourth sensory quadrant.

Conclusion: Irlen Spectral Filters may have an effect on the sensory behaviours exhibited by the students in this study. This effect may have a positive impact in their ability to engage in learning. The findings of this pilot study need to be confirmed with further research.
What impact do Irlen Spectral Filters have on the sensory profile of students who have Autism Spectrum Disorders? A pilot study.

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List of Abbreviations

AAP  American Academy of Paediatrics
ASD  Autism Spectrum Disorder
AASP  Adolescent/Adult Sensory Profile
CHi  Cortical Hyperexcitability Index
DSM-5  Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition
fMRI  Functional magnetic resonance imaging.
MISViS  Meares Irlen Syndrome/Visual Stress
SPD  Sensory Processing Disorder
Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Signature:

Fiona Randall

Date: 18.11.2015
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1. Introduction

The aim of this research is to investigate what impact Irlen Spectral Filters have on the sensory profile of students who have Autism Spectrum Disorders (ASD) with the intention of adding to the understanding of the sensory difficulties experienced by these students, how these difficulties affect behaviour, and how educators may support learner engagement within the educational context. Sensory difficulties have been identified as one of the core issues in learning for students who have ASD (Ashburner, Bennett, Rodger, & Ziviani, 2013; Ashburner, Ziviani, & Rodger, 2008, 2010; Dunn, 2008; Jordan, 2011; Lawson, 2011).

Atypical sensory processing profiles have been found to be present to some degree in over 90% of children and adults with ASD (Leekam, Nieto, Libby, Wing, & Gould, 2007; Tomchek & Dunn, 2007). Sensory processing abnormalities are also considered to be a core feature in ASD and are included in the ASD diagnostic criteria outlined in the latest Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) (American Psychiatric Association, 2013; Tsatsanis & Powell, 2014). For a student with ASD, atypical sensory processing, more commonly referred to as Sensory Processing Disorders ( SPD), has a significant impact on their ability to make sense of the world around them and their ability to function in activities of daily life, including the ability to function within the educational setting (Attwood, 2008a; Ludlow & Wilkins, 2009). In order to cope with their atypical sensory experiences students with ASD often employ a variety of unusual maladaptive behavioural responses that can have a negative impact on student engagement for both the affected student and also for their peers in the classroom (Ashburner et al., 2013; Attwood, 2008a; Biel & Peske, 2009; Dunn, 2008; Grandin & Panek, 2013).

Atypical visual sensory processing and perception is one of the most commonly reported sensory disturbances in children and adults who have ASD (Attwood, 2008a; Dinstein et al., 2012; Grandin, 2009; Grandin & Panek, 2013; Simmons et al., 2009). Vision is one of the primary senses that people use to make sense of the world around them and atypical visual processing can lead to difficulties
in social communication, interaction, behaviour and academic success (Ashburner et al., 2008; Irlen, 2005, 2010; Simmons et al., 2009; Wilkins, 2003).

Irlen Spectral Filters are coloured lenses (spectacles and contact lenses) that are worn to alleviate symptoms associated with atypical visual processing of visual sensory information (Chouinard, Zhou, Hrybouski, Kim, & Cummine, 2012; Irlen, 2005, 2010; Kim, Seo, Ha, & Kim, 2015). There is preliminary evidence to suggest that the use of coloured lenses may relieve some of the sensory symptoms experienced by students who have ASD and SPD (Ludlow, Taylor-Whiffen, & Wilkins, 2012; Ludlow & Wilkins, 2009; Ludlow, Wilkins, & Heaton, 2006, 2008). To date there have been very few studies that specifically address the management of SPD in the educational setting for adolescents and adults with ASD (Grandin & Panek, 2013; Ludlow et al., 2012). Horder, Wilson, Mendez, and Murphy (2014) suggest that successful treatment of sensory symptoms could also reduce some of the core ASD symptoms and related behaviours. Horder et al. (2014) also suggest that by reducing adverse reactions to sensory stimuli it is possible to improve the ASD individual’s overall wellbeing. By evaluating the impact Irlen Spectral Filters have on the overall sensory profile of students who have ASD the author hopes to provide educators with additional insight into the sensory experiences of these students and evidence based methods that can be employed to reduce sensory overload with the aim of improving student engagement within the educational setting.

1.1 BACKGROUND

ASD is a neurological disorder that is defined by persistent and severe deficits in reciprocal social communication and interactions, combined with restrictive repetitive patterns of behaviour, interests or activities. For example, stereotyped or repetitive motor movements, insistence on sameness, highly restrictive interests, and hyper or hypo reactivity to sensory input or unusual interest and responses to sensory stimuli in the environment (American Psychiatric Association, 2013). One of the core features within the restrictive repetitive patterns of behaviour is SPD. Up to 95% of people with ASD experience difficulties with sensory modulation, this means that the ASD brain is unable to process multiple streams of
sensory input effectively which results in inaccurate or distorted sensory perception (Baker, Lane, Angley, & Young, 2008; Tomchek & Dunn, 2007). People make sense of their world through the interpretation of information received through the senses. A person’s perception of reality is created through the processing of sensory information by the nervous system, applying that information to experiences, and conceptualising that information by integrating it with the individuals existing understanding of their world.

ASD is a disorder categorised by dysfunction in the ability to integrate the mind (cognitive processes), body ( SPD ) and relationships (persistent severe deficits in reciprocal social communication and interactions (American Psychiatric Association, 2013; Attwood, 2008a, 2008b; Blackman, 1999). Authors who have ASD such as Blackman (1999) and D. Williams (1999, 2006) have described personal accounts where they have not been able to integrate sensory information coherently. For example Blackman (1999) describes an incident where she was anxious and unable to interpret the emotion in her mother’s face.

Williams (2006) describes her difficulties with integrating sensory information stating:

I couldn’t see a face or a body as a whole, often failed to recognise objects I hadn’t already got to know, found visual chaos overwhelming in its impact on sensory flooding and spent much of my first seven years hypnotised by dancing air particles I could see because of extremely hypersensitive vision (p.127).

Irlen Spectral Filters are worn to relieve symptoms of visual sensory processing disorder believed to be caused by hypersensitivity to light that causes distortions in the perception of text, faces and the surrounding environment. Students who experience these visual distortions can have difficulty with reading, comprehension, fine motor skills, writing, attention deficits, working memory,
organisation, perception of depth, headaches, migraines, and epilepsy (Evans & Stevenson, 2008; Kriss & Evans, 2005; Nandakumar & Leat, 2008). Each of these problems in turn can lead to difficulty with student engagement and academic success (Irlen, 2005, 2010; Kim et al., 2015; Wilkins, 2003).

It has been suggested that many of the unusual stereotyped behaviours displayed by students who have ASD are adaptive behaviours which are an expression of the student’s difficulty in coping with and making sense of sensory information (Baker et al., 2008; Biel & Peske, 2009; Blackman, 1999; Bogdashina, 2003; Dunn, 2008; Grandin & Panek, 2013). Examples of the most commonly observed behaviours expressed in such situations include, inattention, anxiety, withdrawing, self-stimulatory behaviours, compensatory behaviours and defensive behaviours. These behaviours are often deemed to be challenging, disruptive, unacceptable or inappropriate in the context of the classroom and have a negative impact on student engagement for the student with ASD and their peers (Ashburner et al., 2010; Biel & Peske, 2009; Bogdashina, 2003; Dunn, 2008; Grandin & Panek, 2013; Lawson, 2008, 2011).

For students who have both ASD and SPD, the combination of impairments and the unusual cognitive profile produces unique learning strengths and weaknesses (Attwood, 2008b; Blackman, 1999; Lawson, 2011). In order to support learner engagement for these students, it is essential that educators understand the impact that the individual student’s unique sensory profile will have on their ability to actively engage in educational and social activities (Ashburner et al., 2008, 2010; Bogdashina, 2003; Dunn, 2008; Hochhauser & Engel-Yeger, 2010; Lawson, 2008, 2011).

The desire to explore this program of research arose from reading anecdotal accounts about the positive impact that Irlen Spectral Filters have had for improving reading and sensory processing difficulties in individuals who have ASD (Attwood, 2008a; Biel & Peske, 2009; Bogdashina, 2003; Grandin & Panek, 2013; Irlen, 2010; Isaacs & Billet, 2013; D. Williams, 1999). In addition to the anecdotal reports, there have only been a few studies that have investigated the relationship between the use of coloured filters and visual perception in ASD. These studies have also indicated that coloured overlays and precision tinted filters have a positive impact on reading,
perception of faces and the ability to engage in learning activities (Ludlow & Wilkins, 2009; Ludlow et al., 2006, 2008).

Research has identified that SPD and related maladaptive behaviours do have a profound impact on student engagement and academic success for students who have ASD (Ashburner et al., 2013; Ashburner et al., 2008, 2010; Kinnealey et al., 2012; Ludlow et al., 2012). Literacy and numeracy are the core foundations of academic success, without being able to clearly see text and numbers, or be able to successfully engage in the classroom students are highly unlikely to achieve academic success (Jacobs & Richdale, 2013). The intention of this research is to add to the understanding of these difficulties and how educators can address them to support learner engagement within the educational context.

1.2 PURPOSE

The overarching objective of this study is to explore the impact that Irlen Spectral Filters have on the sensory profile of students who have ASD. In doing this the author hopes to provide educators with additional insight into the sensory experiences of the participants and also provide evidence based strategies that can be employed to reduce the sensory symptoms this group of students may experience with the aim of improving student engagement in learning activities.

The tool selected to assess the sensory experience of the participant is the quantitative Brown and Dunn (2002a) Adolescent/Adult Sensory Profile (AASP) tool that contains a Likert scale survey will be used to collect data about the participants’ perceived sensory experiences when they do and when they do not wear Irlen Spectral Filters. The data provided in the AASP will be evaluated by comparing the student’s perceptions of their sensory experience when they wear their Irlen Spectral Filters to their perceptions of their sensory experiences when they do not wear their Irlen Spectral Filters.

For the purpose of this study, a student is defined as a person who is enrolled either part-time or full time in a course of study at a school, college, university, Technical and Further Education or other private registered training organisation.
Only students who identify as having been diagnosed with ASD will be included in the survey. Participants will be asked to complete the Adult Autism Quotient (AQ) questionnaire (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) to validate their self-reported diagnosis.

The theoretical models that have been selected to provide a framework for this thesis will be Peter Jarvis’ holistic learning theory (Jarvis, 2005) and Daniel Siegel’s model of awareness (Siegel, 2012a). Both of these models are based on the integration of the three elements of mind, body (or brain) and relationships. The reason for selecting this approach is that these models reflect the triad of impairments in ASD.

The research question for the project is “What impact do Irlen Spectral Filters have on the sensory profile of students who have Autism Spectrum Disorders?” The implications of these findings will explore possible strategies adult and adolescent students can implement to address the sensory difficulties they experience within the context of the educational setting.

1.3 SIGNIFICANCE

The topic of atypical sensory processing and the associated maladaptive behaviours displayed by students who have ASD is significant because sensory dysfunctions are associated with behavioural and emotional difficulties that lead to decreased participation in social and educational activities, disruption within the classroom, and academic underachievement. Behavioural and emotional problems have also been reported to be the leading cause for the exclusion of ASD students from the mainstream classroom (Ashburner et al., 2010; De La Marche, Steyaert, & Noens, 2012; Hochhauser & Engel-Yeger, 2010; Ludlow & Wilkins, 2009). If the difficulties related to visual sensory dysfunction and sensory overload can be improved, this may subsequently lead to improved learner engagement and academic success for the ASD student (Ashburner et al., 2010; De La Marche et al., 2012; Kinnealey et al., 2012; Ludlow et al., 2012; Ludlow & Wilkins, 2009; Ludlow et al., 2008).
There is a significant gap in the literature in relation to this topic. There are numerous published anecdotal accounts of how the use of precision tinted lenses or filters such as Irlen Spectral Filters reduce sensory perception difficulties for people who have ASD (Attwood, 2008a; Bogdashina, 2003; Grandin & Panek, 2013; Irlen, 2010; Isaacs & Billet, 2013; D. Williams, 1999). The few studies that have investigated the use of coloured overlays and precision tinted, coloured ophthalmic lenses (spectral filters) by children who have ASD indicate that coloured overlays and spectral filters may improve reading ability, the ability to perceive faces and may also reduce symptoms related to atypical sensory processing (Ludlow et al., 2012; Ludlow & Wilkins, 2009; Ludlow et al., 2006, 2008). In the case report by the authors Ludlow & Wilkins (2009) it was found that spectral filters significantly reduced the sensory perception difficulties experienced by the child, improved his behaviour and improved his ability to engage in learning (Ludlow & Wilkins, 2009). In addition to these studies there have also been a number of published anecdotal reports that Irlen Spectral Filters reduce sensory perception difficulties experienced by people with ASD (Attwood, 2008b; Irlen, 2010; Isaacs & Billet, 2013; D. Williams, 1999). Further research investigating the impact the use of coloured lenses such as Irlen Spectral Filters have is warranted (Ludlow et al., 2012; Ludlow & Wilkins, 2009).

1.4 THESIS OUTLINE

In chapter two, the literature regarding the subjects of holistic learning theory, ASD and related SPD has been reviewed, with a particular focus on visual sensory processing dysfunction commonly referred to as Meares-Irlen Syndrome/Visual Stress (Chouinard et al., 2012; Kim et al., 2015; Kruk, Sumbler, & Willows, 2008). The literature about the impact SPD have on student engagement and academic success for students who have ASD have also been reviewed. Studies that suggested methods for addressing difficulties caused by SPD have been discussed along with the implications of the findings of the literature review. Chapter three, the research design used for the project has been outlined, this includes the research methods and methodology used, selection of participants, instruments used, procedures followed,
and the data analysis. Chapter four, the results of the research findings have been documented. The analysis of the results and discussion of the implications of the findings are outlined in chapter five. Lastly, in chapter six, the conclusions have been drawn along with the possible implications and recommendations for future research.
2. Literature review

The literature review will explore the sensory difficulties experienced by students who have ASD, how these difficulties affect the mind, brain and relationships, and what educators can do to support learner engagement within the educational context. This chapter will investigate the literature on the subjects of Jarvis’ (2005) holistic learning theory, Siegel’s (2012a) triad of wellbeing, ASD and the related Sensory Processing Difficulties (SPD). There will be a particular focus on visual SPD, the impact this dysfunction has for students who have ASD and how it affects student engagement and academic achievement. Visual SPD can affect the student’s ability to perceive faces, social cues, perception of text, their reading rate and comprehension of text. These difficulties can have a negative impact on the development of academic skills such as literacy and numeracy (Jordan, 2011; Ludlow, Heaton, Hill, & Franklin, 2013; Ludlow et al., 2012; Ludlow & Wilkins, 2009; Ludlow et al., 2006, 2008). Finally, studies that suggest methods for addressing difficulties caused by visual SPD will also be discussed.

2.1 HOLISTIC LEARNING THEORY AND A MODEL OF WELLBEING

There are many theories that attempt to conceptualise the way in which people learn. For the purposes of this paper, the learning theory selected to provide the framework is the holistic transformational learning theory proposed by Jarvis (2009) complemented with the use of Siegel’s triad of wellbeing (2012a). Both Jarvis’ and Siegel’s models are based on the integration of three key elements of the mind, the body (or brain) and social interactions (relationships). These models were selected as they reflect the core features of ASD which are; impairments in the mind (an unusual cognitive profile), the brain (atypical neuropathophysiology that results in atypical sensory processing function) and relationships (impairments in social interaction and communication) (American Psychiatric Association, 2013; Attwood, 2008a, 2008b; Baird, Douglas, & Murphy, 2011).
Jarvis (2005, 2009) suggests that learning is an existential and experiential process that spans across the lifetime, in which the whole person is moulded physically, mentally and socially through their interaction with the world (Guo, 2010; Jarvis, 2005, 2009; Jarvis & Watts, 2012). He postulates the acquisition of knowledge is a transformational process, which occurs through the integration of the three aspects that create the whole, which are the mind, the body, and social interactions. Jarvis (2009) definition of learning is as follows:

Human learning is the combination of processes throughout a lifetime whereby the whole person – body (genetic, physical and biological) and mind (knowledge, skills, attitudes, values, emotions, meaning, beliefs and senses) – experiences social situations, the content of which is transformed cognitively, emotively or practically (or through a combination) and integrated into the individual person’s biography resulting in a continually changing (or more experienced) person (p.25).

Jarvis describes the mind as the cognitive processes whereby the person integrates information received and processed by the brain to create meaning. The body is considered the physical body. When referring to the physical body, particular emphasis will be placed on the brain and the neurological aspects of receiving and processing information from each of the senses. Relationships include social situations which are affected not only by the people involved but also the context in which they occur (Jarvis, 2009). The particular context that is considered in this research project is the social context of the learning environment within the classroom. Learning is stimulated by our physical and social experiences, with the sensory experiences of sight, sound, touch, smell and taste being fundamental to the whole learning process (Jarvis, 2005, 2009).

Siegel (2012a), presents a triad of human wellbeing (Figure 1.), which is very similar to the learning triad presented by Jarvis. This triad of wellbeing is a model for explaining how a person perceives, and conceptualises their reality, or existence and experiences through the integration of the mind, brain and relationships. Siegel proposes these are not three separate elements but rather three inextricably entwined symbiotic elements of the whole person and through integration of energy between each of these core elements, the person creates their awareness of self and constructs
their reality (2012a, 2012b). Siegel (2012a) states: “If we learn the basic approach of linking differentiated parts of our lives – our nervous systems and our social connections with others – we can move internally and interpersonally toward integration and health” (p.10). If a person is unable to integrate these elements, this will have an effect on their wellbeing and lead to differences in the way in which they perceive their reality. For example people who have ASD can have difficulty with neural integration of sensory information in the brain, cognitive differences that affect their ability to make sense of information, as well as difficulties with social communication and relationships (Attwood, 2008a; Siegel, 2012a).

Over time, there have been many variations in the definition of the mind. This paper will use the definition of the mind proposed by Siegel (2012a) who conceptualises his definition of the mind using what he refers to as the Interpersonal Neurobiology framework. The interpersonal neurobiology framework is based on the following three principles as stated by Siegel (2012a):

![Figure 1. Siegel’s (2012a) three aspects of energy and information flow. Reprinted with permission from The Developing Mind: How relationships and the brain interact to shape who we are. (2nd ed.), by D.J. Siegel (2012) New York: The Guildford Press. Copyright 2012 Mind Your Brain, Inc.](image-url)
1. A core aspect of the human mind is an embodied and relational process that regulates the flow of energy and information within the brain and between brains.

2. The mind as an emergent property of the body and relationships is created within internal neurophysiological processes and relational experiences. In other words, the mind is a process that emerges from the distributed nervous system extending throughout the entire body, and also from the communication patterns that occur within relationships.

3. The structure and function of the developing brain are determined by how experiences, especially within interpersonal relationships shape the genetically programmed maturation of the nervous system.

   To put it simply, human connections create neural connections, and each contributes to mind (Siegel, 2012a, p.3).

In this context energy and information refers to the energy and information received by the sensory system, processed by the brain and conceptualised by the mind. For example, light waves are a form of energy, which is received by the eyes and conveyed to the brain where the energy is processed to create visual information. The mind organises the visual information, integrates it with existing knowledge creating a visual perception of an image and then conceptualises what has been seen, such as the image of a face (Martinez, 2010; Schunk, 2012; Siegel, 2012a). Through social interaction within relationships, the visual information that is received by the sensory system and processed by the brain is then linked to the emotions and experience of the interaction. Therefore, the mind is the relational process used to create meaning from the visual information contained within the image of the face and the emotions associated with the social experience. This aspect of the triad of well-being is important when applied to the holistic learning theory. If the processing of sensory information is dysfunctional, this will alter the way the individual perceives, conceptualises and constructs their reality. For example, if the person is unable to see faces clearly, they will have difficulty seeing and perceiving facial expressions; this can lead to difficulty with integrating the information and conceptualising emotions expressed in the person's face. People who have ASD have been found to have difficulty with perceiving facial expressions and social cues,
which causes difficulties in social interaction and relationships (DePape & Lindsay, 2015; Simmons et al., 2009).

When discussing SPD it is important to consider not only the brain itself as an organ but the whole nervous system, which Siegel refers to as the embodied brain. The embodied brain includes the neural connections that occur within the whole of the extended nervous system, not just the brain as a singular organ (Siegel, 2012a). This is important particularly when considering the mechanisms of the brain in people who have ASD as the ASD brain is wired differently to the typically developing brain and the sensory experiences are also markedly different to those experienced by people with a typically developed brain (Dinstein et al., 2012; Green et al., 2013).

2.2 AUTISM SPECTRUM DISORDERS (ASD)

The American Psychiatric Association (2013) defines ASD as a neurodevelopmental disorder that is characterised by impairments or abnormal functioning in reciprocal social communication and interaction, combined with restricted, repetitive, patterns of behaviour, interests or activities which have a limiting effect on the person’s ability to function normally (American Psychiatric Association, 2013). Research has demonstrated pervasive multimodal sensory abnormalities are experienced by over 90% of individuals who are diagnosed with ASD (Geschwind, 2009; Leekam et al., 2007). Sensory processing abnormalities are now recognised to be a core feature in ASD and have been included in the ASD diagnostic criteria outlined in the latest Diagnostic and Statistical Manual of Mental Disorders 5th Edition (DSM-5) (American Psychiatric Association, 2013; Tsatsanis & Powell, 2014).

Prior to the publication of the DSM-5, there were a number of terms used when referring to ASD. The DSM-IV included four separate disorders, which included autistic disorder, Asperger’s disorder, childhood disintegrative disorder, and pervasive developmental disorder not otherwise specified. In addition to these terms, older publications may have also used terms such as High Functioning Autism and Low functioning Autism. The DSM-5 no longer includes these individual diagnostic
terms. The DSM-5 now contains only one diagnostic term for these conditions, which is ASD.

Over the years, a number of cognitive theories have been proposed to explain the differences in the workings of the ASD mind. Cognition is the broad term used to describe information processing, for example, thinking, learning, reasoning, imagery, belief, and problem solving (Siegel 2012, Attwood 2008, Lawson 2001). The three most widely accepted cognitive theories are (1) Theory of Mind (Baron-Cohen, Leslie, & Frith, 1985), (2) Executive Dysfunction Theory (Frith, 2003) and (3) Weak Central Coherence Theory (Frith, 2003). None of these theories on their own are able to completely account for all of the different facets found in ASD; however, collectively they provide greater insight into the cognitive differences found in those who have ASD.

The first cognitive theory, the Theory of Mind, suggests that people who have ASD have difficulty predicting and interpreting the behaviour of others (Pellicano, 2011). It has been found that people who have ASD can have difficulty with the perception and interpretation of facial expressions and the emotions of others (Simmons et al., 2009). Research has indicated that the ASD brain processes sensory information such as visual stimuli differently and this may lead to difficulty in the perception of facial expressions displayed by others (Simmons et al., 2009). The inability to clearly perceive the emotions expressed by others may result in difficulties with reciprocal social communication and interaction and also potentially lead to increased anxiety caused by uncertainty in social situations and relationships (Kuusikko-Gauffin et al., 2011).

The second cognitive theory is the executive dysfunction hypothesis. Executive functions include the control of actions such as inhibition and impulse control, working memory, the ability to shift attention, the ability to be flexible in thinking patterns, as well as organisational and planning abilities (Attwood, 2008b; Baron-Cohen, 2008; Pellicano, 2011). The executive dysfunction theory of ASD is based on the supposition that developmentally the area of the brain responsible for executive function, the prefrontal cortex, has not developed typically and this is the cause of the autistic restrictive repetitive behaviours, rigid thinking patterns, inflexible concrete thought patterns, as well as lack of inhibition and impulse control (Attwood, 2008b; Baron-Cohen, 2008; Frith, 2003; Pellicano, 2011).
The third cognitive theory of ASD is Weak Central Coherence theory. People who have ASD have difficulty with the coherence of scenes or objects as a whole. There is a tendency among people with ASD to process single elements, rather than multiple elements that comprise the whole (Pellicano, 2011). In describing this perception Attwood (2008b, p. 32) uses a metaphor: “imagine rolling a piece of paper into a tube, closing one eye and placing the tube against the open eye like a telescope and looking at the world through the tube; details are visible but the context is not perceived” (p.32). Brain studies investigating neurological function in people who have ASD have found the ASD brain to be abnormally over responsive to and also lacking inhibition following sensory stimulation (Dinstein et al., 2012; Green et al., 2013; Minshew & Williams, 2007). Neuroscientists refer to this as cortical hyper reactivity and hyper connectivity. The over responsive ASD brain that also lacks inhibition is less effective in processing sensory information, and in turn this can lead to difficulties with perception through the senses (Dinstein et al., 2012; Minshew & Hobson, 2008). For example studies have demonstrated that participants who have ASD have excellent low level perception of visual stimuli, but are poorer and slower at processing high level complex stimuli (Simmons et al., 2009). This means when compared to the typically developing brain, the ASD brain can be quicker and more accurate in processing singular items and single details, but slower and less accurate when processing and integrating information to create complex whole visual scenes or moving objects within a scene. Difficulty with integrating such information can affect the perception of a whole object or scenes and in turn can create problems creating context affecting the person’s ability to conceptualise the information that is being received (Simmons et al., 2009).

2.3 SENSORY PROCESSING DISORDERS (SPD) IN ASD

People perceive and make sense of the world through the senses of sight, sound, vestibular (balance), olfaction (smell), gustation (taste), tactile and proprioception (position and movement of the body) (Bear, Connors, & Paradiso, 2007; Biel & Peske, 2009; Bogdashina, 2003). The various areas of the brain responsible for processing different sensory information overlap and are not
independent of each other; they are interdependent and cross over. One area of processing has an impact on another, for example, vision and hearing (Bear et al., 2007; Eagleman, 2013). Over 90% of people who have ASD also have SPD (Leekam et al., 2007; Tomchek & Dunn, 2007) which often involves multiple sensory domains to varying degrees and this can have an impact on their ability to make sense of the world as well as their ability to establish their sense of self within that world (American Psychiatric Association, 2013; Bogdashina, 2003, 2010; Dunn, 2009; Tavassoli, Miler, Schoen, Nielsen, & Baron-Cohen, 2014; D. Williams, 2006).

Bogdashina (2003, 2010) explained that of all the sensory information received through the senses, 75-80 percent of the information is visual, and that 55 percent of all communication is non-verbal visual communication. When visual perception is impaired or distorted, this will affect the individual’s ability to make sense of the world around them and their ability to interpret non-verbal communication. Authors who have ASD have often reported that they find the world to appear fragmented, confusing, and frightening. They also describe difficulties in establishing “their place” or self within the context of the surrounding environment (Isaacs & Billet, 2013; D. Williams, 1999, 2006).

Isaacs, an author diagnosed with ASD, describes his visual processing difficulties, he explained that he sees his environment as a fragmented 2D image; he struggles with perception of depth and constructing meaning from what he perceives. He also explained that to establish his place within his surroundings, when he was young he would map where he was by touching and feeling his way around a room (Isaacs & Billet, 2013).

D. Williams (1999, 2006) is another author diagnosed with ASD who described a similar experience to that of Isaacs. Williams described seeing and processing only fragments of herself, surroundings, or another person one piece at a time, until those items add up to create a whole scene or person. For example, she described her bedroom to be perceived as a number of individual items that added up to create the impression of her room, items such as the cabinets, shoes on the floor, clothing hung over her radiator. She did not see the room as a whole scene. Williams also described feeling a disconnection between her mind and body as a result of only being able to perceive one part of her body at a time. Williams (2006) articulated her experience of the fragmentation of visual information and the subsequent loss of
context as “meaning blindness” (p.100). She says she sees “everything bit by bit by bit so areas full of movement, or movement through crowds, can be overwhelming” (p.102). She went on to explain that this kind of overwhelming visual sensory experience can also affect other areas of her sensory processing, such as auditory processing, and this can cause her to lose her sense of where her body is in space, or her “sense of simultaneous self and other” (p.102). Both Isaacs (2013) and Williams (1999, 2006) described the same difficulties with the perception of people’s faces, the confusion this causes and the social difficulties they have faced as a result.

Research investigating facial recognition and memory in ASD supports these anecdotal reports (Behrmann, Thomas, & Humphreys, 2006; Grinter et al., 2009; Kuusikko-Gauffin et al., 2011; Simmons et al., 2009). Chien and colleagues (2015) investigated neurological function in ASD in comparison to typically developed brains and found increased levels of dysfunction in the areas of the ASD participants brain that are responsible for processing visual information (such as recognition of motion, biological forms, faces, scenes and objects) and the regions of the brain responsible for social cognition. These differences were positively correlated with increased social difficulties in the ASD participant group. The authors suggested this atypical functional integration among brain regions is an integral component of the atypical neurobiology of ASD.

Grandin and Panek (2013) posed the question “how can you socialise people who can’t tolerate the environment where they’re supposed to be social?”. Atypical sensory processing plays a significant role in participation in social activities (including social activities within the classroom) for those who have ASD (Ben-Sasson, Carter, & Briggs-Gowan, 2009; Hochhauser & Engel-Yeger, 2010; Matsushima & Kato, 2013). A recent study by Tavassoli et al. (2014) investigated sensory over-responsivity in adults with ASD. The authors found that adults with ASD self-reported sensory over-responsivity in multiple sensory modalities. They also found that an increase in the level of sensory over-responsivity was associated with increased autistic related traits. They reported that these sensitivities and traits affect activities of daily living and the quality of life for people with ASD (Tavassoli et al., 2014).

The above examples given by authors Williams, Isaacs, and Grandin provide insight into the ways in which atypical sensory processing in people who have ASD...
can have an impact on their ability to integrate information between the mind, the brain and relationships. This not only has an impact on the overall wellbeing of the student who has ASD, but also on their ability to learn.

2.4 IMPACT OF ASD AND SPD ON STUDENT ENGAGEMENT AND ACADEMIC ACHIEVEMENT

The combination of ASD and SPD often leads to significant learning difficulties that have an impact on the student’s ability to engage in learning activities, which subsequently affects their academic achievement (Ashburner et al., 2013; Ashburner et al., 2008, 2010; Fernandez-Andres, Pastor-Cerezuela, Sanz-Cervera, & Tarraga-Minguez, 2015). The learning difficulties experienced by students with ASD can include impaired cognitive processing, attention deficits, visual perceptual abnormalities, anxiety, impaired self-regulation, poor motor control and consistent impairments in social communication and behaviour (Ashburner et al., 2008, 2010; Fernandez-Andres et al., 2015; Horder et al., 2014; Ludlow et al., 2012; McKeon, Alpern, & Zager, 2013; Sturm, Fernell, & Gillberg, 2004).

Ashburner et al. (2008) observed in a significant proportion of students who have both ASD and SPD their atypical sensory-processing has a negative impact on the ability of the student to engage in cognitive tasks required for learning and this results in academic underachievement. The overall severity of SPD has also been found to be positively associated with ASD symptom severity (Ben-Sasson et al., 2009; Chien et al., 2015). In addition to this, the severity of SPD symptoms is also significantly associated with the level of social interaction difficulties and lack of emotional regulation occurring in people who have ASD (Attwood & Scarpa, 2013; Matsushima & Kato, 2013). People with ASD have reported that SPD can cause difficulties in processing sensory information to the point where the person feels the senses are overwhelmed and they describe the experience of one or more of the senses shutting down which leads to the inability to process sensory information causing the person to become increasingly confused and anxious (Attwood & Scarpa, 2013; Grandin & Panek, 2013; Isaacs & Billet, 2013; D. Williams, 1999, 2006).
Students who have ASD report the chaotic and unpredictable environment within the educational setting causes them considerable stress and anxiety which affects their ability to function in that environment (DePape & Lindsay, 2015; Humphrey & Lewis, 2008; Saggers, 2015). Sensory over-responsivity can lead to maladaptive behaviours that are considered by educators to be challenging, disruptive, illogical, oppositional and inconsistent (Ashburner et al., 2010; Lawson, 2011; McKeon et al., 2013; Miller, Anzalone, Lane, Cermak, & Osten, 2007). Maladaptive behaviours in the classroom are a commonly reported concerns of educators and parents of students who have ASD and have been reported to contribute to the high levels of exclusion of ASD students from mainstream educational settings (Ashburner et al., 2010; Fernandez-Andres et al., 2015; McKeon et al., 2013). Research has indicated that the atypical sensory patterns and the unusual sensory behaviours exhibited by people who have ASD and SPD are correlated with decreased participation in social activities including participation in classroom activities and an increase in social emotional problems during school age (Ben-Sasson et al., 2009; Carnahan, Musti-Rao, & Bailey, 2009; Fernandez-Andres et al., 2015; Horder et al., 2014; Schaaf, Toth-Cohen, Johnson, Outten, & Benevides, 2011).

People who have ASD have described their sensory experiences as causing them difficulties in processing their thoughts and attending to relevant stimuli (Grandin & Panek, 2013; Lawson, 2011; D. Williams, 1999, 2006). Grandin and Panek (2013) have suggested that when a person with ASD is suffering from sensory overload, their way of thinking can become disorganised which makes it hard for them to articulate the problem they are experiencing. Research has supported these anecdotal reports finding that students who have difficulty filtering out irrelevant sensory information (for example the flicker and hum of fluorescent lights) also have difficulty attending to sensory information relevant to learning (Kinnealey et al., 2012). Sturm et al. (2004) studied the behaviours of 101 children who had ASD and were between 5 and 12 years of age. The authors found the majority of the children had difficulties that can have a negative impact on learning. These difficulties included mild to severe attention deficits in 95 (94%) children, mild to severe hyperactivity for 57 (56%) children, and impulse control dysfunction was observed to be severe in 35 (34%) and mild in 16 (15%) children. The authors also reported
that a significant proportion of the children experienced a combination of attention deficits and hyperactivity problems to a mild or severe extent.

The findings of research undertaken by Baruth, Casanova, Sears, and Sokhadze (2010) suggested that individuals who have ASD had abnormally large cortical responses to task irrelevant visual stimuli. The authors hypothesized that these atypical responses to task irrelevant stimuli are suggestive of sensory over reactivity in individuals who have ASD. They also suggested that this sensory abnormality might lead to disruption in visual processing, selective attention and executive function. When considering Jarvis’ (2005, 2009) learning theory whereby learning is stimulated by our physical and social experiences, and where a student’s sensory experiences are fundamental to the whole learning process, a student who has ASD may have difficulty receiving, organising, conceptualising and integrating information which can have a negative impact on their learning.

Atypical visual sensory processing and perception is one of the most commonly reported sensory disturbances in children and adults who have ASD (Attwood, 2008a; Grandin, 2009; Grandin & Panek, 2013). People with ASD and SPD have reported experiencing difficulties with processing visual information in the general environment, with visual communication cues and also the perception and comprehension of written materials (Irlen, 2010; Isaacs & Billet, 2013; D. Williams, 1999, 2006). Anecdotal reports indicate that visual processing difficulties can cause problems with literacy and numeracy due to difficulty seeing words and numbers clearly. Hypersensitivity to light and patterns can cause individuals with ASD to experience fragmented vision, visual chaos, and sensory overload that can lead to some or all of their other senses shutting down, causing confusion and anxiety (Grandin & Panek, 2013; Isaacs & Billet, 2013; D. Williams, 1999, 2006).

Sensory difficulties have been reported to have a great impact on the ability of a person who has ASD to function generally in everyday activities (Attwood, 2008a; Baruth et al., 2010; Bogdashina, 2003; DePape & Lindsay, 2015; Hochhauser & Engel-Yeger, 2010; Horder et al., 2014). Considering this and also the literature which indicates SPD is associated with an increase in ASD symptoms, atypical behaviours, inattention, and academic underachievement, it is worthwhile investigating interventions that may have an impact on reducing difficulties associated with SPD for students who have ASD that may improve their ability to
engage in learning (Dunn, 2008; Grandin & Panek, 2013). It has been suggested that Irlen Spectral Filters are one intervention that has such an effect on the sensory experience of people who have ASD (Attwood, 2008a; Grandin & Panek, 2013; Irlen, 2010; Isaacs & Billet, 2013; Ludlow et al., 2012; D. Williams, 1999, 2006).

2.5 THE USE OF IRLEN SPECTRAL FILTERS

Irlen Spectral Filters are precision tinted (coloured) ophthalmic lenses, contacts lenses or plastic sheets (called overlays) which are used to relieve symptoms related to atypical visual sensory processing (Irlen, 2005, 2010). Irlen Spectral Filters are a particular brand of precision tinted ophthalmic lenses, in addition to the Irlen brand there are other brands of spectral filters available, for example the Cerium range of ophthalmic tinted lenses developed by Wilkins (2003). Research investigating the use of precision tinted ophthalmic lenses for treating symptoms related to MISViS has included both brands of lenses and overlays. For simplicity and clarity, precision tinted ophthalmic lenses are referred to using the term spectral filters and coloured plastic sheets will be referred to as overlays (Beasley & Davies, 2013a, 2013b; Wilkins & Evans, 2010).

![Irlen Spectral Filters and Overlays](image)

*Figure 2. Irlen Spectral Filters and Overlays. Photograph: F.Randall.*
People who use spectral filters have reported experiencing distortions in the perception of text, faces and the surrounding environment. They have also reported experiencing symptoms including visual discomfort (asthenopia, pain in or around the eyes), headache, fatigue, migraine, motion sickness, photosensitive epileptic seizures, photophobia, reduced attention span and poor depth perception (Chouinard et al., 2012; Riddell, Wilkins, & Hainline, 2006; Wilkins et al., 1999; Wilkins & Evans, 2010; Wilkins, Huang, & Cao, 2007). There have been a number of terms used to describe this collection of symptoms and they include Irlen Syndrome, Meares-Irlen Syndrome, Scotopic Sensitivity, Pattern Related Visual Stress, Visual Stress and Meares-Irlen Syndrome/Visual Stress (Chouinard et al., 2012; Irlen, 2005, 2010; Whiting & Robinson, 2001; Wilkins, 2003; Wilkins & Evans, 2010). In respect of the significant contributions made by several researchers investigating this visual processing disorder, this collection of symptoms and the associated visual perceptual dysfunction will be referred to as Meares-Irlen Syndrome/Visual Stress (MISViS) (Chouinard et al., 2012; Kruk et al., 2008).

People with MISViS have reported difficulty with word recognition, words moving on the page, limited word span, poor working memory and attention span. The distortions in the perception of text can lead to difficulty with reading words on a page, white board or computer screen. It can also affect comprehension of text, fine motor skills such as writing, ability to maintain attention, memory retention and recall, as well as organisation. These difficulties can affect the student’s reading ability, their ability to engage in learning activities and their ability achieve academically (Gilchrist & Allen, 2015; Irlen, 2005, 2010; Kruk et al., 2008; Wilkins, 2002, 2003; Wilkins et al., 1994; Wilkins, Huang, & Cao, 2004).

Gilchrist and Allen (2015) described a conceptual model of the process of reading which involves three stages. These stages are illustrated in Figure 3.
Gilchrist and Allen (2015) explained that the three stages in this process of reading require the ability to visually fixate on a word, the visual sensory ability to clearly perceive single words, and to also have a span of recognition that allows for fluency in the construction and perception of sentences and paragraphs. The authors also suggested that MISViS has the potential to affect the cognitive processes involved in reading. They investigated the differences between participants who had a high number of MISViS symptoms, those with low levels of MISViS symptoms and those who did not experience MISViS symptoms. The authors concluded that the results of their study indicated an association between a higher level of MISViS symptoms and poorer reading performance with reduced accuracy in the cognitive process of word recognition. The authors hypothesized this was caused by visual processing differences in the participants who had higher levels of MISViS symptoms (Gilchrist & Allen, 2015). The use of optimal colour in a colorimeter, coloured overlays and spectral filters have been found to improve reading rate, accuracy, fluency and comprehension for both children and adults who report having

It is postulated that MISViS symptoms and distortions are caused by cortical hyperexcitability and a lack of inhibition in the cortex (Braithwaite, Marchant, Takahashi, Dewe, & Watson, 2015; Braithwaite, Mevorach, & Takahashi, 2015; Chouinard et al., 2012; Huang, Cooper, Satana, Kaufman, & Cao, 2003; Wilkins, 2003; Wilkins & Evans, 2010; Wilkins et al., 2004). A functional magnetic resonance imaging (fMRI) study undertaken by Huang and colleagues (2008) demonstrated that that precision ophthalmic tints normalize cortical excitation in the visual areas of the brain, suppressed visual illusion and distortions of pattern related visual stress in migraineurs. A retrospective fMRI case study by Chouinard et al. (2012) investigated the cortical responses of a participant who identified as having MISViS and who did not have a history of migraine or epilepsy. The researchers found the cortical responses of the participant with MISViS were statistically different to those of the controls and were indicative of the participant experiencing an atypical cortical response to the visual sensory stimuli.

Recently a pilot study by Kim et al. (2015) found the use of spectral filters for participants who experienced symptoms of MISViS improved the participants reading speed of by more than twenty percent. The researchers also conducted fMRI investigation into the effect spectral filters had on the brain during reading tasks. The authors found when the participants used their chosen spectral filters during reading tasks there was an increase in the activation in the left middle and superior temporal cortices during sentence reading in comparison to the activation during reading tasks without the use of spectral filters. The authors explained this is significant as these areas of the brain are responsible for sentence comprehension, in particular the integration of semantic and syntactic information within sentences.

When considering the results of Kim, Seo, Ha and Kim’s (2015) study investigating the impact spectral filters have on the brain function of people who experience MISViS symptoms, it is of interest to consider research that has investigated the brain function of people who have ASD. Minshew and Williams (2007), reported that fMRI studies have found striking differences in the patterns of
activation of in the brains of adult participants who had ASD during sentence comprehension when compared to typically developed controls. Through fMRI studies participants with ASD have been found to have intact lower level information processing (for example simple word recognition) and problems with brain connectivity and functioning with higher level information processing tasks (for example language, sentence comprehension, and working memory) (Minshew & Williams, 2007). The differences found in the neural connectivity of the participants with ASD were not dissimilar to differences in connectivity in the study investigating brain function in participants who wear spectral filters.

A study conducted by Whiting and Robinson (2001) evaluated the impact of the use of spectral filters had on word identification, word attack (the ability to break down, sound out and decode unfamiliar words) and facial affect for children aged between 8 and 12 years of age. Of the 69 participants, 38 had learning disabilities related to MISViS and 31 children did not have learning disabilities. They found that prior to the introduction of spectral filters there were marked differences between the two groups in the ability to recognise faces and emotion expressed on faces, and the ability to recognise words out of context. The group who had MISViS symptoms were provided with individually selected spectral filters and the tests were repeated again two months later. The researchers found there was little difference between the MISViS group and the controls in recognition of facial affect after the MISViS group had been wearing their spectral filters for two months.

There have been numerous anecdotal reports that the use of spectral filters has improved visual perception for people who have ASD. These reports include improvements in visual clarity and comprehension of text as well as improvements in general visual perception, including perception of faces, oneself, other people and the surrounding environment (Attwood, 2008a; Biel & Peske, 2009; Blackman, 1999; Bogdashina, 2003; Grandin & Panek, 2013; Irlen, 2010; Isaacs & Billet, 2013; D.

1 There is not a consensus internationally as to what a learning disability is. Learning disability in this Australian context as defined in the Australian Government Commonwealth Law Disability Discrimination Act (1992) as:

(f) a disorder or malfunction that results in the person learning differently from a person without the disorder or malfunction; or (g) a disorder, illness or disease that affects a person’s thought processes, perception of reality, emotions or judgment or that results in disturbed behaviour (Part 1, s.4).
Williams, 1999, 2006). For example, D. Williams (1999) described her experience upon putting on her first pair of spectral filters, she explained “I could read from a distance….without using a finger to trace each line. My eyes read each word in a line without flying off and scanning other words on the page. I read the line with meaning and with feeling” (p.175). Her description illustrates similarities between her visual perceptual experience and findings of the study conducted by Kim et al. (2015). Additionally the description Williams provided of how her spectral filters improved her ability to perceive her partner Ian’s face as a whole is also in keeping with the findings of research investigating the impact spectral filters have on facial perception. She said, “Ian’s face was joined together. His eyes and nose and mouth and chin were all held together with equal impact in a single context” (p.175). It is also of interest to note that she described an improvement in her other sensory experiences, not just her vision, when she wore her spectral filters “The background noise I had always heard before – machine sounds in distant rooms, the hum of traffic, the mutter of people talking in the background – was not even apparent (p.175). Williams’s anecdotal account also indicates that wearing spectral filters improved her ability to integrate and contextualise information she was taking in. She described being able to “take in far more than I ever could before. Everything that was taken in peripherally before was now being taken in directly. But overload didn’t happen; everything seemed more contained, more controlled, less invasive and frightening – it seemed in context” (p.176).

To date there have only been a few studies that have investigated MISViS in people with ASD and the impact that coloured overlays and spectral filters have on reading ability and perceptual performance (Ludlow et al., 2013; Ludlow et al., 2012; Ludlow & Wilkins, 2009; Ludlow et al., 2006, 2008). A study carried out by Ludlow et al. (2006) examined the impact the use of coloured overlays had on the reading rate of nineteen children who had a diagnosis of ASD who were aged from eight years to fifteen years of age and compared them to aged matched typically developing control participants. It was found that 15 of the 19 children who had ASD experienced an improved reading rate of greater than 5%, where in comparison only three of the 19 children in the control group demonstrated an improved reading speed of greater than 5%. More than half of the children with ASD who experienced an improved reading rate with the use of coloured overlay had a significant
Ludlow et al. (2008) published findings of a study that investigated the effect coloured overlays had on visual perceptual performance of children who have ASD. They undertook several experiments designed to evaluate the impact the use of coloured overlays had on the participants reading ability and their ability to perceive images of everyday objects. The authors found that when the ASD children who experienced symptoms of MISViS used coloured overlays they experienced improvements in speed and improvements in the ability to perceive objects. The authors suggested that the findings of these experiments support the notion that coloured overlays can be of benefit in improving perception of text, reading rate, reading accuracy and the perception of printed images for children who have ASD.

Following on from their earlier studies, Ludlow and Wilkins (2009) wrote a case report describing the changes observed in a student who had ASD and SPD following the introduction of spectral filters. Prior to the introduction of coloured spectral filters the student suffered headaches, nausea, projectile vomiting, difficulty with perception of depth and reported being very sensitive to smells, strobe lighting and glare from reflections in mirrors and windows. He also reported to experiencing what he called “hot eyes” and what his mother described as periods of “burn out” where he would sleep for a number of days. The student’s reading ability, sensory profile and reported symptoms were recorded before the introduction of coloured spectral filters, immediately after receiving the spectral filters and after 24 months of consistent use of the spectral filters. It was reported that in the 24 months following the introduction of the spectral filters, the student experienced a significant reduction in sensory sensitivities, episodes of nausea and vomiting, “hot eyes” and “burn out”. He was also reported to have had an increase in willingness to participate in social activities as well as improvement in his academic achievement in standardised attainment tests at school. The improvements documented by Ludlow and Wilkins in this case report were likened to the improvements Williams (1999) described experiencing after she commenced wearing spectral filters.

Ludlow, Taylor-Whiffen and Wilkins (2012) reported the findings of a further study which evaluated the impact the use of coloured overlays had on the participants reading rate and their performance on the children’s version of the “reading the
mind in the eyes” test, developed by Baron-Cohen, Wheelwright, Spong, Scahill, and Lawson (2001). In the reading the mind in the eyes test the participants were required to look at images of eyes and choose from a selection of four words that might describe that emotion (Ludlow et al., 2012). Participants included fifteen students who had ASD aged between eight and seventeen years of age and a group of age and sex matched typically developing controls. The researchers found that the performance of the participants with ASD was significantly poorer than the control group in the number of emotions identified without the use of an overlay. They also found that eleven of the fifteen participants with ASD showed a significantly better performance in the recognition of emotions when using an overlay. In contrast, there was not a significant improvement in performance of emotion recognition among the control group with the use of an overlay. Ludlow et al. (2012) also noted that the participants who read faster with an overlay also correctly identified more emotions with the use of an overlay. The findings of this study investigating the use of colour for participants with ASD were similar to the findings of the study conducted by Whiting and Robinson (2001) (discussed earlier) where the authors reported that the use of spectral filters improved the perception of faces of participants who experienced symptoms related to visual stress.

2.6 IMPLICATIONS

The review of the literature indicates the combined disorders of ASD and SPD can have a negative effect on the ASD student’s ability to engage in learning and also their academic achievement (Ashburner et al., 2008). The literature suggests the use of spectral filters may improve the sensory perceptual experiences of students who have ASD (Ludlow et al., 2012; Ludlow & Wilkins, 2009). People who have ASD and who wear spectral filters have reported improvements in visual processing as well as improvements in their overall sensory experience and their ability to contextualise the information they are taking in (Attwood, 2008a; Blackman, 1999; Isaacs & Billet, 2013; D. Williams, 1999, 2006).

Sensory processing abnormalities have been demonstrated to be positively correlated with increased levels of autistic trait scores and symptoms of anxiety in
adults who have ASD (Horder et al., 2014). It has also been proposed that the behaviours related to sensory experiences are associated with academic underachievement in students who have ASD (Ashburner et al., 2008). Given the negative impact that sensory processing abnormalities have on the ASD student’s emotional wellbeing, behaviour and engagement in educational activities, it is worthwhile investigating interventions that may reduce difficulties associated with SPD.

To date there have not been any published peer reviewed studies that have progressed from the investigation of the use of coloured overlays to evaluating the effect that spectral filters have on visual perception and the sensory profile for students who have ASD. As mentioned previously, sensory difficulties can have a negative impact on the ASD students’ ability to function within the context of the classroom. It has been suggested that spectral filters can improve clarity of text, reading rate, comprehension and perception of social cues. Anecdotal accounts have indicated that wearing spectral filters not only improves the ability to process visual sensory information, but can also improve the overall sensory experience, improving the ability to process other sensory information such as sound, touch and improved body connectedness. It has also been reported that the spectral filters have contributed to improvements in the ability to function in social situations as well as within the classroom setting (Bogdashina, 2003; Isaacs & Billet, 2013; Ludlow & Wilkins, 2009; D. Williams, 1999, 2006). The purpose of this study was to evaluate the impact that the use of Irlen spectral filters have on the sensory profile of students who have ASD.
3. **Research design**

### 3.1 METHODOLOGY

The study was a pilot study because a study of this nature has not been conducted previously. Everitt (2003) defines a pilot study as a “small scale investigation designed either to test the feasibility of methods and procedures for later use on a large scale, or to search for possible effects and associations that may be worth following up in a subsequent larger study” (p.163). A single subject design was used to evaluate the reported sensory profile of students who have ASD and who wear spectral filters.

### 3.2 PARTICIPANT RECRUITMENT AND PROCEDURE

#### 3.2.1 PARTICIPANT SELECTION AND INCLUSION

For the purpose of this study, a student has been defined as a person who at the time of completing the survey was enrolled in either a part-time or a full time course of study at a secondary school, college, university, technical and further education or other private registered training organisation. The target participants for the research project were adolescent and adult students (aged 16 years of age or older) who wear Irlen Spectral Filters and who reported to have a diagnosis of High Functioning Autism or Asperger’s Syndrome. People with low functioning Autism are considered to have an Intelligence Quotient (IQ) of less than 70 and were not targeted for this research survey (Baron-Cohen et al., 2005). Individuals who have a diagnosis of High Functioning Autism or Asperger’s Syndrome are considered to have average, or above average intelligence and are not considered to have an intellectual disability (Attwood, 2008a; Baron-Cohen et al., 2005; Wing, 2005). While there is some debate over informed consent for students who have ASD, those students who have a diagnosis of High functioning Autism or Asperger’s Syndrome are considered to have the cognitive capacity to provide informed consent (Attwood, 2008a; Baron-Cohen et al., 2005). For clarity and consistency, the newer diagnostic
term of ASD (American Psychiatric Association, 2013) has been used when referring to the participants who identified as having a diagnosis of High Functioning Autism or Asperger’s Syndrome.

3.2.2 PARTICIPANT SELECTION INSTRUMENT

The tool that was used to confirm the participants self-report of an ASD diagnosis was the adult Autism Spectrum Quotient (AQ) (Baron-Cohen, Wheelwright, Skinner, et al., 2001) questionnaire. The AQ is comprised of 50 statements designed to be used as a self-reporting screening tool to assess the level of autistic behaviours reported by the individual. The respondent answers “Definitely Agree”, “Slightly Agree, “Slightly Disagree” or “Definitely Disagree” to each of the 50 statements. The AQ has been found to be an effective and reliable tool in screening adults for ASD (Horder et al., 2014; Woodbury-Smith, Robinson, Wheelwright, & Baron-Cohen, 2005). The reported acceptable cut off score when using the AQ as a screening tool is 26 (Woodbury-Smith et al., 2005). Therefore, participants who self-reported a formal diagnosis of ASD and who achieved an AQ score of 26 or more were included in the study.

3.2.3 DATA COLLECTION INSTRUMENT

The data collection method chosen for the study was a non-intrusive quantitative closed response Likert style self-report questionnaire, the Adolescent/Adult Sensory Profile (AASP) developed by authors Brown and Dunn (Brown & Dunn, 2002a; McIver, 1981). The Brown and Dunn AASP questionnaire is widely accepted and has been found to be both a valid and reliable tool (Crane, Goddard, & Pring, 2009; Dunn, 1999; Engel-Yeger & Dunn, 2011; Horder et al., 2014). The AASP Self Questionnaire asks the person completing the self-report to provide details of their name, age, the date questionnaire was completed, their birthdate and gender. In addition to these fields, there is an open ended question on the cover page which asks “Are there aspects of daily life that are not satisfying to you? If Yes, please explain” (Brown & Dunn, 2002a, 2002b). Instructions on how to complete the survey are also provided on the cover page of the questionnaire. The instructions advise the person to answer the questions in the following manner:

Almost never: When presented with the opportunity, you

almost never respond in this manner (about 5% or less of the time).
Seldom: When presented with the opportunity, you **seldom** respond in this manner (about 25% of the time).

Occasionally: When presented with the opportunity, you **occasionally** respond in this manner (about 50% of the time).

Frequently: When presented with the opportunity, you **frequently** respond in this manner (about 75% of the time).

Almost always: When presented with the opportunity, you **almost always** respond in this manner (about 95% or more of the time) (Brown & Dunn, 2002b, p.23).

Within the Brown and Dunn (2002b) AASP questionnaire there are 60 Likert style questions, including dual scaling questions. The questions are presented as statements that reflect the respondent’s sensory experience. Examples of these statements include, “I avoid elevators and/or escalators because I dislike the movement” (p.84), “I keep the shades down during the day when I am at home” (p.85), and “I find it hard to concentrate for the whole time when sitting in a long class or a meeting” (p.86).

Each questionnaire takes approximately 15 minutes to complete (Brown & Dunn, 2002b; Crane et al., 2009; Horder et al., 2014). Each question asks how often the participant exhibits a particular behaviour in various situations. The questions are structured to identify behaviours that indicate low sensory registration, sensation seeking, sensory sensitivity and sensation avoiding. These four sensory quadrants are derived from Dunn’s model of sensory processing and are described as:

1. **Low registration**: the brain requires higher levels of stimuli to generate a response to sensory stimuli. This leads to what Dunn describes as a passive behavioural response (Brown & Dunn, 2002b; Crane et al., 2009; Dunn, 2009).

2. **Sensation seeking**: the brain requires higher levels of stimuli and the individual actively seeks sensory stimulation. Leading to active behavioural responses (Brown & Dunn, 2002b; Crane et al., 2009; Dunn, 2009).
3. Sensory sensitivity: Lower levels of stimuli are required to create a response within the brain. Sensory sensitivity can lead to passive behavioural responses (Brown & Dunn, 2002b; Crane et al., 2009; Dunn, 2009).

4. Sensation avoiding: the brain requires lower levels of stimuli to generate a sensory response. Active behavioural responses to stimuli include behaviours aimed at avoiding or reducing the stimuli the person cannot tolerate (Brown & Dunn, 2002b; Crane et al., 2009; Dunn, 2009).

In response to each question in the AASP the participant selects from the following options; “Almost Never”, “Seldom”, “Occasionally”, “Frequently”, and “Almost Always” (Brown & Dunn, 2002a; Dunn, 1999; Horder et al., 2014; Kaplan, 2004; Ludlow & Wilkins, 2009). After scoring, an individualized profile of sensory processing across the four sensory quadrants can be created. The profile indicates where an individual’s sensory processing differs from the norm (Brown & Dunn, 2002a; Dunn, 1999).

3.3 PROCEDURE AND TIMELINE

Ethical clearance was received from the University of the Sunshine Coast Human Research Ethics Committee, ethical clearance number HREC: S/13/563. The participants’ surveys were de-identified. The participants were considered to have given implied consent when they chose to participate in the study by voluntarily requesting, completing and returning the survey to the research team. The returned surveys have been secured in a locked filing cabinet on campus. The research project information sheet (RPIS) was placed on the research page of Professor Tony Attwood’s website (http://www.tonyattwood.com.au/index.php/research-studies). A copy of the RPIS can be found in Appendix B. The RPIS was circulated via social media using the chief investigator Fiona Randall’s Facebook page, twitter account and Linked In account. Participants were directed to contact the chief investigator via email to request a copy of the research survey.
A research recruitment sheet calling for participants was placed on noticeboards at various locations at the University of the Sunshine Coast campus. A copy of the recruitment sheet is provided in Appendix C. The flyers directed students to obtain a copy of the research survey either by emailing the chief investigator or by going to the university disability services department, Student Life and Learning, in person and requesting an envelope containing the research survey. Each student who nominated to participate in the study was provided with a copy of the survey. The survey included the RPIS, a cover letter containing screening questions and instructions on how to complete the three questionnaires as well as the AQ and two AASP questionnaires. To de-identify the surveys, the participant number was written on each of the survey tools prior to posting the survey to the participant. The cover letter also instructed participants not to write their names on the survey. A copy of the cover letter is provided in Appendix D. Participants were also provided with a reply paid envelope to return the survey by post to the chief investigator. The restrictions of the Pearson Publishing copyright of the AASP necessitated the use of the hard copy AASP being distributed through the traditional postal system.

Participants were asked to complete the AQ questionnaire once and the AASP questionnaire twice. Participants completed one AASP questionnaire to indicate their sensory experiences when they do not wear their spectral filters and the other AASP questionnaire was completed to indicate what their sensory experiences is when they do wear their spectral filters. To address the potential for bias, every second participant was asked to complete the AASP questionnaires in the reverse order.

3.4 DATA ANALYSIS

The AASP self-questionnaires were scored by an Occupational Therapist and the results of each individual participant’s two AASP questionnaires were compared to evaluate their sensory profile when they do not wear their spectral filters and their sensory profile when they do wear their spectral filters.
4. Results

In total, 15 individuals responded to the call for participants for the study. Surveys were not sent to nine of these people as the information they provided when they expressed an interest in participating in the study indicated they did not meet the selection criteria for the study. In all, six participants were sent a copy of the survey. Of these six participants, five returned the survey to the research team. One participant did not score above 26 on the AQ and so was excluded from the study. Another did not complete the AQ in full and they did not fully complete one of the AASP questionnaires. Therefore, only three participants met the criteria for inclusion in the study. The participants AQ responses and demographic information are presented in Table 1.

Table 1

<table>
<thead>
<tr>
<th>AQ scores and responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant</td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>Participant No.1 Kim*</td>
</tr>
<tr>
<td>Participant No.2</td>
</tr>
<tr>
<td>Participant No.3</td>
</tr>
<tr>
<td>Participant No.4 Nicki*</td>
</tr>
<tr>
<td>Participant No.5</td>
</tr>
<tr>
<td>Participant No.6 Sue*</td>
</tr>
</tbody>
</table>

* To maintain confidentiality, the participants’ surveys were de-identified and each participant who met the inclusion criteria has been given a pseudonym.

Participants were asked to complete the AASP questionnaire twice, once to reflect their experiences when they do not wear their Irlen Spectral Filters, and the second time to reflect their experiences when they do wear their Irlen Spectral filters.
The participants’ sensory behavioural response patterns for the four sensory quadrants of low registration, sensation seeking, sensory sensitivity, and sensation avoiding are presented in Table 2, Table 3 and Table 4. The participants’ raw scores for each of these quadrants are displayed in Figure 4, Figure 5 and Figure 6. The highest possible score that can be attained for each AASP quadrant is 75 (Brown & Dunn, 2002b). The three participants AASP results are presented separately as individual cases.

4.1 AASP RESPONSES: KIM

Kim, age 16, Female.

Kim did not respond to the question “Are there aspects of daily life that are not satisfying to you?” on either of the two AASP questionnaires.

Kim’s sensory processing preferences are presented in Table 2.

<table>
<thead>
<tr>
<th>AASP Sensory Quadrant</th>
<th>Without Irlen Spectral Filters</th>
<th>With Irlen Spectral Filters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low registration</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Sensation seeking</td>
<td>=</td>
<td>=</td>
</tr>
<tr>
<td>Sensory sensitivity</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Sensory avoiding</td>
<td>++</td>
<td>++</td>
</tr>
</tbody>
</table>

- - Much less than most people = less than 2% of the typically developing standardisation sample
- Less than most people = between 2 and 16% below the typically developing standardisation sample
= Similar to most people = between 16 and 84% of the typically developing standardisation sample.
+ More than most people = between greater than 84% and 98% of the typically developing standardisation sample.
++ Much more than most people = greater than 98% of the typically developing standardisation sample. (Brown & Dunn, 2002b)

Kim’s responses on the AASP questionnaires indicate that her sensory experiences in the quadrants of low registration, sensory sensitivity and sensory avoiding are not similar to most people. Kim indicated that she exhibited behaviours related to low
registration, sensory sensitivity more than most people. Kim also indicated that she exhibits sensory avoiding behaviours much more than most people. Kim’s overall scores did not vary to such an extent that her sensory processing classification altered between the two conditions. However, she did indicate differences in her sensory behaviours when she does wear her Irlen Spectral Filters. Kim’s variations in sensory scores for each of the quadrants are illustrated in Figure 4.

![Figure 3. Kim’s variation in scores between the two conditions.](image)

### 4.2 AASP RESULTS: NICKI.

Nicki, age 51, Female.

Nicki responded to the question “Are there aspects of daily life that are not satisfying to you?” on both of the AASP questionnaires. Her responses to this question are as follows:

When she does not wear her Irlen lenses: “Of course there are. For example I hate multi-tasking!”

When she does wear her Irlen lenses: “Yes, it’s hard to quickly explain this.”

Nicki’s sensory processing preferences are presented in Table 3. The variations between the scores for each of the conditions are illustrated in Figure 5.
Nicki’s responses on the two AASP questionnaires indicate that her sensory experiences are quite different to those of most people. She has indicated in her responses that she exhibits behaviours of Low registration, Sensory Sensitivity and sensory avoiding much more than most people. Nicki has also indicated that she exhibits behaviours of sensory seeking less than most people. Nicki’s raw sensory scores varied between the two conditions when she does not wear her Irlen Spectral Filters and when she does wear her Irlen Spectral Filters. Her scores for each of the sensory quadrants for both conditions are illustrated in Figure 5.

<table>
<thead>
<tr>
<th>AASP Sensory Quadrant</th>
<th>Without Irlen Spectral Filters</th>
<th>With Irlen Spectral Filters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low registration</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Sensation seeking</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sensory sensitivity</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Sensory avoiding</td>
<td>++</td>
<td>++</td>
</tr>
</tbody>
</table>

- - Much less than most people = less than 2% of the typically developing standardisation sample
- Less than most people = between 2 and 16% below the typically developing standardisation sample
  = Similar to most people = between 16 and 84% of the typically developing standardisation sample.
+ More than most people = between greater than 84% and 98% of the typically developing standardisation sample.
+ + Much more than most people = greater than 98% of the typically developing standardisation sample. (Brown & Dunn, 2002b)
4.3 AASP RESULTS: SUE

Sue, age 41, Female.

Sue responded to the question “Are there aspects of daily life that are not satisfying to you?” on both of the AASP questionnaires. Her responses to this question are as follows:

When Sue does not wear her Irlen Spectral Filters: “Over sensory problems (sic) – melt downs the world isn’t easy to live in. Too much (sic). Limitations take away from quality of life. Light limits my activities. Can’t go outside or watch TV. Extreme pain + headaches. Can’t be w/o (sic) my lenses on.”

When Sue does wear their Irlen Spectral Filters:

I can’t read well if at all. My speech and spelling is messed up (sic). I can’t go outside during the day because the sun is too bright. Headaches. Seizures. Very limited activities even w/my (sic) lenses on. But it’s a lot better then w/o (sic) my lenses I can do more things w/them (sic) on. My sensory overload + communication issues (sic).

Sue’s sensory processing preferences are presented in Table 4.

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Sue’s sensory behavioural responses.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASP Sensory Quadrant</td>
<td>Without Irlen Spectral Filters</td>
</tr>
<tr>
<td>Low registration</td>
<td>+ +</td>
</tr>
<tr>
<td>Sensation seeking</td>
<td>- -</td>
</tr>
<tr>
<td>Sensory sensitivity</td>
<td>+ +</td>
</tr>
<tr>
<td>Sensory avoiding</td>
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</tr>
</tbody>
</table>

- - Much less than most people = less than 2% of the typically developing standardisation sample
- Less than most people = between 2 and 16% below the typically developing standardisation sample
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+ More than most people = between greater than 84% and 98% of the typically developing standardisation sample.
++ Much more than most people = greater than 98% of the typically developing standardisation sample. (Brown & Dunn, 2002b)

Sue has indicated in her responses to the two AASP questionnaires that her sensory experiences are very different to those of most people. Her sensory
behaviours in the quadrants of low registration, sensory sensitivity and sensory avoiding are exhibited much more than most people. Her responses indicated her sensation seeking behaviours are exhibited much less than most people. Sue’s raw scores varied between the two conditions. Sue’s raw scores indicating her experiences when she does not wear her Irlen Spectral Filters, and when she does not wear her Irlen Spectral Filters are illustrated in Figure 6. Of the three participants, Sue’s scores have varied the most between the two conditions.

Figure 5. Sue’s Variation in scores between the two conditions.
5. Discussion

The aim of this study was to investigate the Impact that Irlen Spectral Filters have on the sensory profile of students who have Autism Spectrum Disorders. Using the Brown and Dunn (2002a) AASP, this study compared the sensory processing profiles of students who have ASD when they do not wear Irlen Spectral Filters to their sensory processing profile when they do wear Irlen Spectral Filters. Each participant’s responses to the AASP for both conditions (with and without spectral filters) have been compared.

Each of the included participants’ AQ scores was 32 or greater (Table 1). A score of 32 or above on the AQ is considered to indicate clinically significant autistic traits (Crane et al., 2009; Woodbury-Smith et al., 2005). Out of a possible total score of 50, Kim scored 32, Nicki scored 35, and Sue scored 41. Horder et al. (2014) found that sensory behaviours were highly correlated with AQ scores in adults. It is of interest to note that the frequency in which the participants indicated they exhibited atypical sensory behaviours was higher in the participants who had the higher AQ scores. These results are similar to the findings reported by Horder et al. (2014).

All three participants indicated variations in their sensory behaviours between when they did not wear their Irlen Spectral Filters and when they did not wear their Irlen Spectral Filters. The participants experienced variations in each of the sensory quadrants of low registration, sensation seeking, sensory sensitivity and sensation avoiding. Kim (Figure 4) demonstrated a reduction in her scores for atypical sensory processing in three of the four quadrants when she wears her Irlen Spectral Filters. Nicki (Figure 5) and Sue (Figure 6) indicated reductions in their scores for atypical sensory processing across all four quadrants. However, the variations in the participants’ total scores in each of the quadrants were not great enough to cause a change in any of their quadrant profile classifications (Table 2, Table 3, & Table 4). The participants’ reduction in the sensory behaviours exhibited when they do wear their Irlen Spectral Filters are similar to the experiences reported by people who have ASD and who wear Irlen Spectral Filters (Attwood, 2008a; Bogdashina, 2003; Isaacs & Billet, 2013; D. Williams, 1999, 2006). This reduction is also similar to the findings of a case study carried out by Ludlow and Wilkins (2009).
Two of the three participants indicated in their comments that they feel they have variations in their sensory experiences when they do not wear their Irlen Spectral Filters in comparison to when they do wear their Irlen Spectral Filters. Nicki and Sue provided these comments in their answers to the question, “Are there aspects of daily life that are not satisfying to you?” On the AASP that was answered to reflect her experiences when she does not wear her Irlen Spectral Filters, Nicki responded, “Of course there are. For example, I hate multi-tasking! (sic)” On the AASP reflecting her experiences when she does wear Irlen Spectral Filters she wrote “Yes, it’s hard to quickly explain this.” Her responses to the sensory profile statement “I work on two or more tasks at the same time” reflect the changes she experiences when wearing her Irlen Spectral Filters. Without lenses she responded that she can only work on two or more tasks at a time about 5% or less of the time. However, when she does wear them she is able to work on two or more tasks about 50% of the time. The way in which Nicki has answered these questions indicates she experiences a significant improvement in her ability to work on two or more tasks at the same time, or to “multi-task.” Within the context of the classroom setting, students are often required to carry out more than one task at once. For example, students may be required to take notes whilst listening to the instructions of the educator. The improvement the participant indicated that her Irlen Spectral Filters have made is likely to also improve her ability to engage in learning activities.

Sue provided more detail in her response to the question “Are there aspects of daily life that are not satisfying to you?” On the AASP questionnaire reflecting her experiences when she does not wear her Irlen Spectral Filters she wrote: “Over sensory problems (sic) – melt downs the world isn’t easy to live in. Too much (sic). Limitations take away from quality of life. Light limits my activities. Can’t go outside or watch TV. Extreme pain + headaches. Can’t be w/o (sic) my lenses on.”

Indicating her experiences when she does wear her Irlen Spectral Filters she wrote:

I can’t read well if at all. My speech and spelling is messed up (sic). I can’t go outside during the day because the sun is too bright. Headaches. Seizures. Very limited activities even w/my (sic) lenses on. But it’s a lot better then w/o (sic) my lenses I can do more things w/them (sic) on. My sensory overload + communication issues (sic).
This participant describes sensory experiences that are having a significant impact on her daily activities, and though her Irlen Spectral Filters do not eliminate her sensory issues, she feels it is a lot better when she does wear them. Her AASP sensory profile shows that she is extremely sensitive to sensory stimuli and exhibits a very high number of atypical sensory behaviours. Her responses in the two AASP questionnaires indicate the largest reduction in her AASP score when wearing her Irlen Spectral Filters (Figure 6). This participant also had a very high AQ score (Table 1). The participant’s description of her sensory experience, her sensory profile scores and her AQ scores are reflective of the findings of research carried out by Horder et al. (2014). Horder et al. demonstrated that high AQ scores are correlated with an increase in sensory sensitivity, anxiety and autistic behaviours in people who have ASD. The participants reduced scores on the sensory profile and her reported improvement when wearing her Irlen Spectral Filters are similar to the findings of research and anecdotal reports that indicate Irlen Spectral Filters have an effect of reducing problems related to visual stress for people who have ASD, migraine and epilepsy (Ludlow et al., 2013; Ludlow & Wilkins, 2009; Wilkins et al., 1999; Wilkins et al., 2007).

All three participants indicated changes in their sensory processing experiences for several of their senses when they do wear their Irlen Spectral Filters. The senses assessed in the AASP included Taste/Smell processing, movement processing, visual processing, touch processing, activity processing, and auditory processing. Participant no.1 indicated changes in her sensory processing experiences in five of the six senses when she does wear Irlen filters (Figure 4). Nicki (Figure 5) and Sue (Figure 6) indicated changes in all six of the senses assessed in the AASP. The participants atypical experience with sensory difficulties, migraines and seizures is not uncommon in people who have ASD (Casanova, 2008; Danielsson, Gillberg, Billstedt, Gillberg, & Olsson, 2005; Minshew & Williams, 2007; Sullivan, Miller, Nielsen, & Schoen, 2014). The improvement she has described is also reflective of the literature investigating the use of Spectral Filters to reduce difficulties associated with visual sensory processing, migraines, and seizures (Ludlow et al., 2013; Ludlow & Wilkins, 2009; Wilkins et al., 1999; Wilkins & Evans, 2010; Wilkins et al., 2007).
Reflecting on Jarvis’ theory of learning (Jarvis, 2005, 2009, 2011; Jarvis & Watts, 2012) and Siegel’s model of wellness (Siegel, 2012a), the ability to integrate information between mind, brain and relationships is not only a core element of the learning process, but also key factor in the student’s wellbeing. Any improvements that the participants may experience in their ability to process and integrate sensory information could possibly lead to improvements in their ability to engage in learning and their overall sense of wellbeing.

Students who exhibit behaviours related to low registration quite require higher levels of stimuli to cause them to respond to the stimuli. Examples of behaviours related to low registration that may cause a student to have difficulties within the classroom include; not responding when someone calls their name, having to ask people to repeat what has been said, missing visual or verbal cues (such as signs), tripping or bumping into things and being forgetful (Brown & Dunn, 2002b; Dunn, 2008, 2009). Improvements in this sensory quadrant might lead to improvements in a student’s ability to hear and process what has been said within the setting of the classroom. The student may also experience improvements with attending to visual cues and remembering information.

Students who display behaviours of sensation seeking require higher levels of stimuli to cause a behavioural response. Examples of behaviour related to sensation seeking that can cause the student to experience difficulties in the classroom include; fidgeting, touching, tapping or rubbing objects, chewing on things, humming or making odd noises (Biel & Peske, 2009; Brown & Dunn, 2002b; Dunn, 2009). These behaviours have also been referred to as self-stimulatory behaviours (Baker et al., 2008; Biel & Peske, 2009). Self-stimulatory behaviours are often considered to be challenging and inappropriate by educators and these behaviours can also create disruption in the classroom and have an impact on student engagement for the ASD student and their class peers (Ashburner et al., 2010; Biel & Peske, 2009; Bogdashina, 2003; Dunn, 2008; Grandin & Panek, 2013; Lawson, 2008, 2011).

Students who are sensitive to sensory stimuli require lower levels of stimuli to elicit a behavioural response to the stimuli (Brown & Dunn, 2002b). Examples of behaviours that a student may demonstrate that are related to sensory sensitivity include flinching at loud noises, placing their hands over their ears, and squinting or shading their eyes in bright lighting. Students who experience sensory sensitivity
may also dislike strong odours, clothing that feels rough to touch, and strong tastes in food (Dunn, 2008, 2009). These students can find the environment in the classroom to be very distracting. For example, they may find the brightness, flicker and hum of fluorescent lights distracting, or the conversations of other students difficult to ignore (Ashburner et al., 2010; Brown & Dunn, 2002b; Dunn, 2009).

Students who require lower levels of stimuli to create a sensory response often exhibit sensation avoiding behaviours in an attempt to actively avoid the stimuli that causes them discomfort (Brown & Dunn, 2002b; Dunn, 2008, 2009). For example, they may choose to avoid loud unpredictable environments such as large department stores. In the context of the educational setting students may find loud classrooms distressing and might become irritable or withdraw from group activities (Brown & Dunn, 2002b; Dunn, 2008, 2009).

Each of the three participants indicated changes in their sensory behavioural preferences in their responses to the AASP statements when they wear their Irlen Spectral Filters. The changes that the participants have reported in their sensory experiences in each of the four AASP quadrants will be discussed in relation to their responses to various items in the AASP questionnaire.

5.1 LOW REGISTRATION

In the sensory quadrant of low registration, Kim was classified to experience behaviours demonstrating low registration more than most people (Table 2) (Brown & Dunn, 2002b). Nicki and Sue both indicated they exhibited behaviours related to low sensory registration much more than most people (Brown & Dunn, 2002b). Each of the participants’ scores for low registration demonstrated a reduction in the score for the exhibition of behaviours in this quadrant when the participant wears their Irlen Spectral Filters. The reduction in their scores for low registration indicates that they may experience improved sensory registration when wearing their Irlen Spectral Filters. The improvements reported by participants are reflective of the improvements described in both the anecdotal reports of authors who have ASD and wear Irlen Spectral Filters (Isaacs & Billet, 2013; D. Williams, 1999, 2006), and the findings reported in research articles (Ludlow & Wilkins, 2009; Ludlow et al., 2008).
Questions in the Brown and Dunn (2002b) AASP which relate to low registration of sensory experiences include statements such as, “I miss the street, building, or room signs when trying to go somewhere new” (p.66), “I trip or bump into things”(p.65), and “I am unsure of footing when walking on stairs (for example I trip, lose balance, and/or need to hold the rail)” (p.65). Students attending high school, college and university are often required to move from classroom to classroom, navigating their way along busy pathways and hallways. Classrooms can often be cluttered with chairs, desks and other materials. If the student has difficulties with low registration, the student may find it more challenging than most people to navigate their way around within the classroom and with transition between classrooms. The experiences reported by the participants are similar to the reports of who have ASD (Isaacs & Billet, 2013; D. Williams, 1999, 2006). Williams and Isaacs both describe having difficulties with navigating their way around their environment as a result of visual processing difficulties, both authors reported that these difficulties were improved with the use of Irlen Spectral Filters.

An improvement in the domain of low registration could also indicate improvements in the student’s ability to hear and process what has been said within the classroom. Examples of statements in the Brown and Dunn (2002b) AASP relating to low registration included “I have trouble following what people are saying when they talk fast or about unfamiliar topics” (p.67) and “I have to ask people to repeat things” (p.67). Both Kim and Sue indicated that they experience an improvement with these sensory difficulties when they do wear their Irlen Spectral Filters. For example, Kim indicated that when she does not wear their Irlen Spectral Filters, that about 95% or more of the time she has trouble following what people are saying when they talk fast or about unfamiliar topics. This only happens about 75% of the time when she does wear her Irlen Spectral Filters. In another example, Sue indicated a significant change in her response to the statement “I have to ask people to repeat things”. She indicated that this happens about 95% or more of the time when she does not wear her Irlen Spectral Filters. She indicates this only occurs occasionally, or about 50% of the time when she does wear her Irlen Spectral Filters. Improvements in the ability to hear and follow what is being said within the classroom may also improve a student’s ability to understand and follow verbal instructions and oral teachings.
5.2 SENSATION SEEKING

In the sensory quadrant of sensation seeking (Brown & Dunn, 2002b), Kim was classified to experience behaviours demonstrating sensation seeking similar to most people, whereas, Nicki’s score indicates she exhibits these behaviours less than most people. Lastly, Sue indicated she exhibited these behaviours much less than most people. Statements in the Brown and Dunn (2002b) AASP that relate to sensation seeking included the following statement related to visual processing: “I like to go places that have bright lights and that are colourful” (p.66). Kim indicated when she does not wear her Irlen Spectral Filters she answered “seldom” (about 25% of the time). Her answer to this statement when she wears her Irlen Spectral Filters was “occasionally” (about 50% of the time). Classrooms are often brightly lit and colourful places. It has been reported that bright lighting may cause the ASD student to become over stimulated and to experience an increase in maladaptive repetitive behaviours and inattention (Ashburner et al., 2010; Winterbottom & Wilkins, 2009). A decrease in bright lighting has been reported to lead to a decrease in maladaptive behaviours, and increased student engagement in the classroom (Kinnealey et al., 2012; Ludlow & Wilkins, 2009; Winterbottom & Wilkins, 2009). Kim’s altered preferences when wearing her Irlen Spectral Filters may indicate an improvement in her ability to tolerate a setting with bright lights that is colourful, such as a classroom. It may also indicate an improvement in her ability to engage in learning in a brightly lit and colourful setting.

For the Brown and Dunn (2002b) statement “I do things on the spur of the moment”(p.67), to reflect her experience when she does not wear her Irlen Spectral Filters, Kim answered “Frequently” (about 75% of the time). When she does wear her Irlen Spectral Filters she answered “almost never” (about 5% or less of the time). This indicates a significant change in her behavioural preferences and a reduction in spontaneity, which may possibly indicate a reduction in impulsive behaviours and an improvement in the ability to sustain attention. People who have ASD can have difficulties with inattention and impulsive behaviours that can have a negative impact on the ability of the ASD student to engage in learning (Ashburner et al., 2010; Biel
In response to the visual processing statement, “I like to wear colourful clothing” (Brown & Dunn, 2002b, p.66), both Nicki and Sue reported changes indicating that they are more likely to wear colourful clothing when they do wear their Irlen Spectral Filters. For example, Sue indicated that she “almost never” wears colourful clothing when she does not wear her Irlen Spectral Filters, however, when she does wear them this changed to “occasionally”. The participants’ responses indicate they are more likely to tolerate bright colours when wearing their Irlen Spectral Filters. This improvement may enable the participants to tolerate more colour, not only in their clothing, but also more colour in their surrounding environment in the classroom. The changes indicated by these participants desire to seek colour when wearing their Irlen Spectral Filters are similar to the changes experienced by the student in Ludlow and Wilkins (2009) case report and also the Ludlow et al. (2013) case report.

Ludlow et al. (2013) hypothesized that colour phobias in a child with Autism were related to hypersensitivity to the colours the child disliked. The authors also hypothesized that autistic children displayed hyposensitivity to colours that they actively seek. This hypothesis is in keeping with Dunn’s explanation of sensation seeking behaviours (Brown & Dunn, 2002b). The child in the case report demonstrated an improved ability to tolerate colour when wearing Spectral Filters along with a reduction in his symptoms of headaches and nausea related to his colour sensitivity (Ludlow & Wilkins, 2009). It has been reported that hypersensitivity to light and colour can cause a person who has autism to experience headaches and nausea (Ludlow et al., 2013; Wilkins & Evans, 2010). If either of the participants were to experience headaches, nausea or other discomfort related to colour hypersensitivity, the changes they have indicated may have a negative impact on learning engagement and academic achievement. An improvement in these symptoms could also result in the student experiencing an improvement in their ability to function within the mainstream classroom (Ludlow et al., 2013; Ludlow & Wilkins, 2009).
5.3 SENSORY SENSITIVITY

In the sensory quadrant of sensory sensitivity (Brown & Dunn, 2002b), Kim was classified to experience behaviours demonstrating sensory sensitivity more than most people. Nicki and Sue’s sensory scores indicated that they both exhibit behaviours associated with sensory sensitivity much more than most people do.

In the category of movement processing, all three participants indicated a reduction in sensory sensitivity when they do wear their Irlen Spectral Filters. In response to the statement “I become dizzy easily” (Brown & Dunn, 2002b, p.65), both Kim and Nicki answered “almost always” (about 95% of the time) when they do not wear their Irlen Spectral Filters. Both Kim and Nicki indicated that when they do wear her Irlen Spectral Filters they only become dizzy easily “occasionally” (about 50% of the time). Sue also experienced an improvement, their response changed from “occasionally” becoming dizzy without Irlen Spectral Filters, to “seldom” when she does wear her Irlen Spectral Filters. These responses indicate the participants experience a change in their ability to process movement when wearing Irlen Spectral Filters.

A second sensory seeking statement related to movement processing was “I dislike the movement of riding in a car” (Brown & Dunn, 2002b, p.65). Both Nicki and Sue reported that they disliked the movement when riding in a car and that this improved when they wear their Irlen Spectral filters. The participants sensory experience with and without the use of Irlen Spectral Filters is similar to the reports found in the literature on this topic. People who have autism have been reported to have difficulty with movement processing (Attwood, 2008a; Ludlow & Wilkins, 2009; D. Williams, 1999, 2006). Research findings have suggested a reduction in difficulty with motion processing with the use of colour and Spectral Filters (Ludlow & Wilkins, 2009; Wilkins & Evans, 2010). This reduction has also been reported to contribute to improvements in participation in learning activities within the mainstream school environment (Ludlow & Wilkins, 2009).
5.4 SENSATION AVOIDING

All three of the participants indicated that they exhibit behaviours of sensory avoiding much more than most people (Tables 2, 3, & 4). Kim indicated a slight increase in her score for sensory avoiding behaviours when she does wear her Irlen Spectral Filters (Figure 4). Whereas Nicki and Sue indicated a reduction in their sensation avoiding behaviours when wearing their Irlen Spectral Filters. Sue demonstrated the largest reduction in her score, which went from a score of 73 out of a possible score of 75 when she does not wear her Irlen Spectral Filters, down to a score of 57 out of a possible score of 75 when she does wear her Irlen Spectral Filters (Figure 6).

Nicki and Sue both indicated that when they do wear their Irlen Spectral Filters, they experienced changes to varying degrees that indicated a reduction in their sensory avoiding behaviours related to visual stimuli and visual processing.

Sensory avoiding behaviours related to visual processing were represented in the Brown and Dunn (2002b) AASP questionnaire by the following statements: “I keep the shades down during the day when I am at home” (p.66), “I chose to shop in smaller stores because I’m overwhelmed in large stores” (p.66), and “I limit distractions when I am working (for example, I close the door, or turn off the TV)” (p.66).

The Brown and Dunn (2002b) sensory avoiding statement related to visual processing “I keep the shades down during the day when I am at home” (p.66), relates to behaviours for avoiding bright light. Nicki indicated that when she does not wear her Irlen Spectral Filters she keeps the shades down during the day about 98% of the time when she is at home. When she wears her Irlen Spectral Filters she indicated that she only does this about 50% of the time. As mentioned previously in the section discussing the quadrant of sensation seeking, classrooms are often brightly lit environments, with the use of fluorescent lighting adding to the existing natural light source (Winterbottom & Wilkins, 2009). Reduction in the participant’s sensation avoiding behaviours may also indicate a reduction in their sensitivity to light. This may have a positive impact on the participant’s ability to engage in learning, as it did for the student whose behavioural improvements were discussed in Ludlow and Wilkins (2009) case report.
The second Brown and Dunn (2002b) statement, relates to large stores, these stores often present a highly stimulating visual environment. Sue indicated that when she does not wear her Irlen Spectral Filters she chooses to shop in smaller stores about 75% of the time because she becomes overwhelmed in large stores. However, when she does wear her Irlen Spectral Filters she only exhibits this visual sensory avoiding behaviour about 25% of the time. Sue’s sensation avoiding behaviours when shopping are relevant for the reason that classrooms are also often highly stimulating sensory environments. If the sensory difficulties that cause the student to become overwhelmed can be improved, this may subsequently lead to an improvement in the number of maladaptive behaviours exhibited by Sue. It may also lead to an improvement in the levels of stress and anxiety experienced by Sue. It has been suggested that such improvements could lead to improved learner engagement and academic success for the ASD student (Ashburner et al., 2010; De La Marche et al., 2012; Kinnealey et al., 2012; Ludlow et al., 2012; Ludlow & Wilkins, 2009; Ludlow et al., 2008)

In response to the last Brown and Dunn (2002b) statement that refers to the respondents ability to process visual stimuli in the presence of distractions. Nicki indicated that when she does not wear her Irlen Spectral Filters she almost always limits distractions, which is about 95% or more of the time. When she does wear her Irlen Spectral Filters she indicated that she only does this about 75% of the time. Her responses indicate that when she wears her Irlen Spectral Filters, she feels the need to limit distractions less often. Her response indicating she can be easily distracted is in keeping with the literature that demonstrates students with ASD have difficulty attending to stimuli relevant to learning (Ashburner et al., 2010; De La Marche et al., 2012; Kinnealey et al., 2012; Ludlow et al., 2012; Ludlow & Wilkins, 2009; Ludlow et al., 2008).

In summary, each of the participants reported changes in their sensory experiences and the exhibition of sensory behaviours on their AASP questionnaires when they do wear their Irlen Spectral Filters. The AASP scores for each participant were altered in each of the sensory quadrants. All of these changes involved a reduction in scores, except for Kim who had a slight increase in the quadrant of sensory avoiding when wearing her Irlen Spectral Filters. It is not clear why the participant reported this change. The reduction in the number of sensory behaviours
exhibited in the sensory quadrants could possibly lead to improvements in the participants’ ability to engage in learning and improve their academic achievement (Ashburner et al., 2008; Attwood, 2008a, 2008b; Bogdashina, 2003; Irlen, 2005, 2010; Ludlow & Wilkins, 2009).
6. Conclusions

6.1 CONCLUSIONS

The question posed for this research project was “What impact do Irlen Spectral Filters have on the sensory profile of students who have Autism Spectrum Disorders?” People who have ASD have reported that Irlen Spectral Filters have reduced the number of sensory processing difficulties that they experience in their day-to-day life, and within the context of the mainstream classroom (Attwood, 2008a; Irlen, 2005, 2010; Ludlow et al., 2013; Ludlow et al., 2012; Ludlow & Wilkins, 2009; Ludlow et al., 2006, 2008; D. Williams, 1999, 2006). These reports have been supported by research investigating the use of coloured overlays and Spectral Filters for improving visual perception in reading, perception of faces and the perception of objects (Kim et al., 2015; Ludlow et al., 2013; Ludlow et al., 2012; Ludlow & Wilkins, 2009; Ludlow et al., 2006, 2008).

Sensory processing difficulties are a core feature of ASD with over 90% of people who have ASD experiencing difficulties with more than one of the senses (Leekam et al., 2007; Tomchek & Dunn, 2007). Sensory processing difficulties may cause a student who has ASD to have problems with maladaptive behaviours, social difficulties and emotional difficulties (Ashburner et al., 2008, 2010; Hochhauser & Engel-Yeger, 2010; Horder et al., 2014; Matsushima & Kato, 2013). The topic of atypical sensory processing and the associated maladaptive behaviours displayed by students who have ASD is significant because sensory dysfunctions are associated decreased participation in educational activities, they can cause disruption within the classroom, and may contribute to academic underachievement (Ashburner et al., 2008, 2010; Horder et al., 2014).

The process of learning requires the successful integration of information between mind, brain and relationships (Jarvis, 2005, 2009, 2011; Jarvis & Watts, 2012; Siegel, 2007, 2012a). If a student has difficulty with processing and integrating sensory information this can have an effect on the way that they conceptualise and create meaning from their experiences (Siegel, 2012a). Not only can altered sensory perception affect a person’s ability to learn, it can also have an effect on their sense
of wellbeing (Siegel, 2012a). The impact of sensory difficulties on the wellbeing of people who have ASD was demonstrated by research undertaken by Horder et al. (2014). Their study demonstrated that higher levels of sensory processing difficulties have been correlated with a higher number of autistic behaviours and increased levels of anxiety in people who have ASD and SPD (Horder et al., 2014).

The areas of the brain that are responsible for processing sensory information from each of the senses are interdependent. They are interrelated and rely on the integration of information from other areas of the brain which are also involved in processing sensory information from the other senses (Bear et al., 2007; Eagleman, 2013). The difficulties that people who have ASD that are caused by atypical sensory processing have been found to have a negative effect on their emotional wellbeing, student engagement, social participation and academic achievement (Ashburner et al., 2008, 2010; Hochhauser & Engel-Yeger, 2010; Horder et al., 2014). It is therefore reasonable to postulate that if it is possible to improve sensory processing for one of the senses, such as visual processing, that this may have an impact on the ability to process and integrate information from the other senses.

If it is possible to reduce behaviours and difficulties that are associated with atypical sensory processing, it is also reasonable to postulate that this may lead to an improvement in the ability to engage in learning activities and academic achievement. Within the context of Siegel’s (2012a) model of wellbeing, an improvement in the ability to integrate sensory information could also lead to improvements in the person’s overall sense of wellbeing. Therefore, interventions that may reduce sensory processing difficulties for students who have ASD are worthwhile investigating.

To date there have been very few studies investigating the impact that spectral filters and overlays have on the sensory experiences of children and adults with ASD (Ludlow et al., 2013; Ludlow et al., 2012; Ludlow & Wilkins, 2009; Ludlow et al., 2006, 2008). Studies have indicated that the use of spectral filters and overlays improves sensory perception for people who have ASD (Ludlow et al., 2013; Ludlow et al., 2012; Ludlow & Wilkins, 2009; Ludlow et al., 2006, 2008). People who have ASD have also reported to experience improvements in their sensory experiences when wearing spectral filters (Attwood, 2008a; Bogdashina, 2003; Isaacs & Billet, 2013; D. Williams, 1999, 2006). This pilot study is the first
study to use the AASP to assess the impact that Irlen spectral filters have on the sensory experience of adolescent and adult students who have ASD. The findings of this study indicate that the use of spectral filters has had the effect of reducing the participants’ sensory scores on the AASP. In addition to these results, Sue also commented that she feels aspects of her daily life are “a lot better” with her Irlen Spectral Filters than it is without them. She stated, “I can do more things w/them (sic) on”.

6.2 LIMITATIONS

There were a number of limitations identified in this study. Firstly, very few people expressed an interest in participating in the study. Only five participants returned the research survey, of these only three of the participant’s responses were able to be included in the study, and all three were female. This is not representative of the population of people who have ASD. Studies have indicated that the ratio between males and females who have autism could be as high as five to one (Wingate et al., 2014). With such low numbers, it is not possible to generalize the findings of the study. It is only possible to reflect on the perceived experiences of each individual participant when they do and when they do not wear their Irlen Spectral Filters.

A significant limitation of this study was selection bias. Only participants who already possessed and wore Irlen Spectral Filters were included in this study. The students who nominated to participate in the study have invested in the purchase and the use of their Irlen Spectral Filters. Irlen Spectral Filters (tinting) costs approximately $275 in Australia. This personal investment is could contribute to participant bias in their responses to the AASP. The participants are people who have chosen to purchase and wear Irlen Spectral Filters believe they are beneficial and this may have influenced the way that they have responded to the AASP.

It is important to note that there is a lack of consensus among researchers, health care professionals and educators about the efficacy of spectral filters for treating visual sensory processing symptoms associated with MISViS. There is significant debate between those who are against the use of spectral filters and those
who support the use of spectral filters. For example, an opinion piece by Williams, who is an ophthalmologist (2014), criticising the use of spectral filters for treatment of visual stress created a lively debate between researchers, health care professionals and educators who were either for or against the use of spectral filters. Other criticisms of the use of spectral filters were been made by the American Academy of Paediatrics (AAP) (2009). The AAP review included a limited selection of articles relating to MISViS, and in their report they state: ‘scientific evidence does not support the efficacy of eye exercises, behavioural vision therapy, or special tinted filters or lenses for improving long-term educational performance in these complex paediatric neurocognitive cognitive conditions’ (AAP, 2009, p. 37). Despite the disagreements regarding the efficacy of spectral filters, there is sufficient literature to indicate that exploring this area of research is supported (Boyle & Jindal-Snape, 2012). Recently, authors Boyle and Jindal-Snape (2012) undertook a review of the literature and made the following remark when they addressed the AAP report: “there are many methodologically robust studies that quite clearly indicate support for these types of intervention as significant improvements in reading are evident”(p.169). Brain studies investigating the use of spectral filters have also indicated that filters are of benefit and more research is required in this field (Huang et al., 2011; Kim et al., 2015; Wilkins et al., 1999; Wilkins et al., 2007).

Several limitations that apply to this study involved the use of the Brown and Dunn (2002b) AASP tool. The Pearson Publishing copyright did not allow the AASP to be reproduced electronically in any form. Therefore, the research team were unable to conduct an electronic survey and the research survey had to be posted to participants. This may have contributed to the difficulty with recruiting participants. To eliminate the need to use the traditional postal system, future studies could employ a different sensory assessment tool may be used in electronic format as an online survey.

The Brown and Dunn (2002b) AASP is comprised predominantly a closed questions that limited the responses of the participant. Within this survey, there was a space provided with the word “comments” written under each group of questions for each area of sensory processing. This tool is normally used in the presence of a clinician to answer any questions the person completing the survey may have (Brown
& Dunn, 2002b). The clinician may also prompt them to add any additional comments in the comments sections. The participants’ completed the AASP on their own and none of the three participants provided any additional information in the comments sections of the AASP.

There are only ten questions in the AASP that specifically relate to visual sensory processing which limits the ability to evaluate changes in visual perceptual experiences. The AASP was not specifically designed for evaluating each of the senses separately. The intent of the tool is to evaluate a person’s overall sensory profile, which includes their sensory behavioural patterns related to low registration, sensation seeking, sensory sensitivity and sensory avoiding. Future studies aiming to investigate the impact that spectral filters have on visual sensory processing may wish to utilise another tool that was published recently, which is the Cortical Hyperexcitability Index (CHi). The CHi is a self-report proxy measure developed by researchers Braithwaite, Marchant, et al. (2015) and was designed with the specific purpose of evaluating the level of cortical hyperexcitability experienced in response to visual stimuli. The authors explain the tool was developed as they identified there was an absence of a formally established and reliable measure of MISViS or what they refer to as cortical hyperexcitability (Braithwaite, Marchant, et al., 2015).

6.3 IMPLICATIONS

The findings of this study could have implications for future research investigating the impact the use of Irlen Spectral Filters has on the sensory experiences of students who have ASD. Future studies could explore what affect the use of lenses has on the ASD student’s ability to engage in learning activities and their ability to achieve academically.

This study has implications for adolescent and adult students who have ASD and SPD. Research has indicted that atypical sensory experiences are associated with academic underachievement (Ashburner et al., 2008, 2010). It would be beneficial for students to have an understanding of their sensory profile and the effect that
atypical sensory behaviours may have on their ability to engage in learning and achieve academically (Dunn, 2008, 2009). Understanding their own unique sensory needs may assist students who have ASD in advocating for their sensory needs in the educational setting. A better understanding of their sensory behaviours may also assist the student to identify and implement strategies to manage their sensory responses to particular stimuli. This could include the use of spectral filters for students who experience visual processing difficulties that are associated with MISViS.

The responses of the participants in this study indicate they have experienced changes in their sensory modulation behaviours in each of the sensory quadrants when they do wear their Irlen Spectral Filters. The degree to which they have experienced changes is not possible to measure using the AASP scores. In future studies, it would be beneficial to consider methods in which researchers can obtain more descriptive accounts of the perceived experiences of students who have ASD and wear Irlen Spectral Filters. Such descriptive responses would shed more light on the difficulties these students experience with visual perception and sensory processing.

Another avenue of investigation in future studies could involve the use of fMRI to evaluate cortical responses of people who have ASD and wear Irlen Spectral filters. There are similarities between the neurological cortical hyper excitation theory of ASD (Dinstein et al., 2012; Green et al., 2013; Minshew & Williams, 2007) and the neurological cortical hyper excitation theory of MISViS (Braithwaite, Marchant, et al., 2015; Braithwaite, Mevorach, et al., 2015; Chouinard et al., 2012; Huang et al., 2003; Wilkins, 2003; Wilkins & Evans, 2010; Wilkins et al., 2004). Brain studies have indicated a reduction in cortical hyper excitation with the use of Spectral Filters for people who experience signs and symptoms of MISViS (Wilkins et al., 1999; Wilkins et al., 2007). It would be beneficial for future research to investigate what affect spectral filters have on the neurological responses to sensory stimuli for people who have ASD. Such studies could be used to test the hypothesis of cortical hyper excitation in people who have ASD and who wear Irlen Spectral Filters.

In conclusion, the atypical sensory experiences of students who have ASD and SPD can have a significant impact on their ability to engage in learning and their
ability to achieve academically. The findings of this study indicate that Irlen Spectral Filters have possibly had an effect on improving aspects of the student’s perceived sensory experiences. Irlen Spectral Filters may be a treatment intervention that could possibly improve the sensory experiences of other people who have ASD and SPD. More research is required to determine whether Irlen Spectral Filters improve the ability of students who have ASD and SPD to engage in learning and achieve academic success.


Williams, G. (2014). Irlen syndrome: expensive lenses for this ill defined syndrome exploit patients. *BMJ, 349*. doi: 10.1136/bmj.g4872


Appendices

APPENDIX A: PERMISSION TO USE MODEL OF WELLBEING.

Hi Fiona,

As long as you properly cite it then yes, you may use it.

Best,

Whitney

On Sat, Mar 14, 2015 at 8:24 PM, Fiona Randall <j001@student.usc.edu.au> wrote:

Dear Dr. Siegel,

I am a Master of Education (by Research) student at the University of the Sunshine Coast (USC) in Queensland Australia. I am writing to you to request permission to use your Triangle diagram depicting the three aspects of energy flow please. (Figure 3.1 p.8 The Developing Mind).

My research project is investigating the impact that Irlen Spectral Filters have on the sensory profile of students who have Autism Spectrum Disorder (ASD). I am using the Pearson Publishing Brown and Dunn Adolescent/Adult Sensory Profile tool to undertake a comparison of the participants experience when they do wear their lenses and when they do not wear their lenses.

I wish to use the information flow triangle as a framework for discussing the impact that abnormal sensory processing has on the integration of information between Mind Brain and Relationships for Autistic students.

The research participant information sheet is available on Professor Tony Attwood’s website:

What impact do Irlen spectral filters have on the sensory profile of students who have Autism Spectrum Disorders? A pilot study.
Tony’s web site is a guide for parents, professionals, people with Asperger’s Syndrome, and their partners
Read more...

If you are happy for me to use your diagram can you please advise me what formal steps I need to take to obtain permission from the publishing company?
I am also happy to provide a copy of my ethics approval application and the draft introduction for my thesis.

Thank you,

Fiona Randall

RN, BSc (Nursing), MEd (student)

--

Best regards,

Whitney Stambler
Director of Communications & Operations
310-451-0335
1137 Second Street, Suite 119
Santa Monica, CA 90403

www.DrDanSiegel.com
www.MindfulInstitute.com
www.facebook.com/DrDanSiegel
twitter.com/DrDanSiegel
APPENDIX B: RESEARCH PROJECT INFORMATION SHEET

What impact do Irlen spectral filters have on the sensory profile of students who have Autism Spectrum Disorders? A pilot study.

Ethics approval number: HREC: 5/13/563

Purpose
You are invited to take part in this project to allow us to evaluate the impact that Irlen spectral filters have on the sensory profile of students who have Autism Spectrum Disorders.

Contacts
The research team consists of Chief Investigator Mrs Fiona Randall Master of Education Student (USC), Associate Professor Deborah Heck (Head of the Education Department at USC and Principal Supervisor), Dr Ann Kennedy-Behr (Lecturer Occupational Therapy at USC and co-supervisor) and critical friend Professor Tony Attwood (Adjunct Professor, School of Psychology, Griffith University).

Please direct questions to:
Fiona Randall  
Email: f.randall@student.usc.edu.au  
Phone: +61 7 5313 3598

Associate Professor: Deborah Heck  
Email: dheck@usc.edu.au  
Phone: +61 7 5456 5112

Participant experience
We are inviting students who wear Irlen spectral filters, who are 16 years of age or older and who have been formally diagnosed with either High Functioning Autism or Asperger’s Syndrome to complete the survey. If you agree to take part in this survey, it will take approximately 45 minutes of your time. You will be asked to complete the survey in three sections. These sections include an Autism-Spectrum Quotient and two further sections about your sensory perception experience when you do not wear your Irlen spectral filters and when you do wear your Irlen spectral filters.

Risks and benefits
There are no specific risks involved in this research project. Your data will be non-identifiable. While you will not receive any direct benefits for participating, your information will help us to understand the impact that Irlen spectral filters have on the sensory profile of people who have Autism Spectrum Disorders.

Participation and consent
Participation in the review is voluntary, and you may discontinue at any time without penalty. As your survey responses will be non-identifiable, it will not be possible to withdraw your responses after you have submitted them. Consent will be implied by completion and submission of the survey. Consent is for the use of your results in this project as well as future related research projects.

Confidentiality and results
Your responses to this survey will be completely anonymous, and no member of the research team will know who has participated. A summary of findings of this study will be available on the University of the Sunshine Coast Research Bank website, http://research.usc.edu.au/retal/access/manager/index. Non-identifiable results may be presented at external or internal conferences or meetings, or by publication.

Complaints / Concerns
If you have any complaints about the way this research project is being conducted you can raise them with the Chief Investigator or, if you prefer an independent person, contact the Chairperson of the Human Research Ethics Committee at the University of the Sunshine Coast: (c/- the Research Ethics Officer, Office of Research, University of the Sunshine Coast, Maroochydore DC 4558; telephone (07) 5459 4574; email: humanethics@usc.edu.au). The researchers and the University of the Sunshine Coast thank you for consideration of this study.

The researchers and the University of the Sunshine Coast thank you for consideration of this study.
APPENDIX C: RESEARCH PROJECT RECRUITMENT SHEET/FLYER

RESEARCH PROJECT RECRUITMENT SHEET

What impact do Irlen spectral filters have on the sensory profile of students who have Autism Spectrum Disorders? A pilot study. (HREC approval number HREC/S/13/563)

DO YOU WEAR IRLEN GLASSES?

We are looking for participants in a research project about the impact of Irlen spectral filters on the sensory profile of students who have Autism Spectrum Disorders.

To participate in the research survey you need to:
- Be a **Student** aged 16 years or older, AND
- Wear Irlen lenses, AND
- Have either **Autism Spectrum Disorder or Asperger’s Syndrome**.

For a copy of the survey & research project information sheet please email Fiona Randall *f_r001@student.usc.edu.au* OR

Go to Disability Services at Student Life and Learning, Building E.

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APPENDIX D: COVER LETTER

What impact do Irlen spectral filters have on the sensory profile of students who have both Irlen Syndrome and Autism Spectrum Disorders? A pilot study.

Ethics approval number: HREC: S/13/563

Thank you for agreeing to participate in this research project.

In the research package you have been sent, you will find enclosed the following items:

1. Research Project Information Sheet
2. The Autism Quotient Questionnaire
3. Two copies of the Adult/Adolescent Sensory Profile
4. A reply paid envelope.

This survey is anonymous.

DO NOT WRITE YOUR NAME ON THE QUESTIONNAIRES OR THE REPLY PAID ENVELOPE.

Please answer the following questions:

Have you read and understood the Research Project Information sheet? □ Yes □ No

Are you aged between 16 years and 26 years of age? □ Yes □ No

Do you wear Irlen Spectral Filters (Irlen glasses or contact lenses)? □ Yes □ No

Did you purchase your Irlen glasses/contacts from an Irlen Diagnostician or clinic? □ Yes □ No

Are you currently a student enrolled in either part time or full time study? □ Yes □ No

Are you enrolled as a student at a school, college, university, TAFE or other Registered Training Organisation (RTO)? □ Yes □ No

Have you been diagnosed with Asperger's Syndrome or High Functioning Autism? □ Yes □ No

If you have answered yes to all of the questions listed above you are eligible to participate in this research project.

❖ Please complete the enclosed Autism-Spectrum Quotient Questionnaire.

❖ Please complete the other sensory profile questionnaire and answer the questions to indicate what your sensory experience is when you DO wear your Irlen filters (glasses/contact lenses).

❖ Please complete one sensory profile questionnaire and answer the questions to indicate what your sensory experience is when you DO NOT wear your Irlen filters (glasses/contact lenses).

❖ Please use the reply paid envelope to return this sheet along with the three questionnaires to the research team.