A Sequential Mixed-Methods Approach to Exploring the Use of Multi-Sensory Environments with Autistic Children

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Thesis summary

Multi-Sensory Environments (MSEs) are common in special-needs schools and contain equipment that change the sensory environment for educational or therapeutic benefit. They are widely used with autistic individuals, but the existing evidence base is limited and there are no best-practice guidelines to support practitioners. This thesis presents a series of novel studies investigating MSE use with autistic children. A sequential mixed methods study was used to assess the beliefs and experiences of practitioners who use MSEs with autistic children (Chapter 2). Among the key findings, the practitioners reported that a range of behavioural and cognitive benefits were possible from MSE use and said that giving the child control can improve outcomes. These findings were used to design an MSE and observational coding system (Chapter 3) to empirically test how autistic children use MSEs. Assessing 41 autistic children aged 4-12 years in an MSE (Chapter 4), it was found that having control over the sensory environment led to an overall reduction in repetitive motor behaviours, sensory seeking behaviours and an improvement in attention. However, anxiety, enjoyment and levels of arousal were unaffected by condition, and there was only limited evidence of a change in social communication. Preferences of the autistic children for the different MSE equipment were also empirically tested (Chapter 5), with the bubble tube and touch, sound and light board being most preferred. Preference was affected by sensory profile, IQ, and age, but not autism severity. In summary, this thesis presents the largest study to date on autistic children within an MSE and establishes that the way MSEs are used affects behaviour. The findings have practical implications for practitioners wanting to maximise the benefit of MSEs for their autistic pupils.

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Soli Deo Gloria

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List of abbreviations

ABA	Applied Behavioural Analysis
ADHD	Attention Deficit Hyperactivity Disorder
ADOS	Autism Diagnostic Observation Schedule
ANOVA	Analysis Of Variance
AOC	Alertness Observation Checklist
APA	American Psychiatric Association
ASC-ASD	Anxiety Scale for Children-Autism Spectrum Disorder
ASD	Autism Spectrum Disorder
BC	Behaviour Checklist
BOSCC	Brief Observation of Social Communication Change
BPI-01	Behaviour Problem Inventory
BRS	Behavioural Relaxation Scale
CAB	Checklist of Challenging Behaviour
CASS	Contextual Assessment of Social Skills
CB	Challenging Behaviour
CBT	Cognitive Behavioural Therapy
CUCHDS	Cardiff University Centre for Human Developmental Science
DISCO	Diagnostic Interview for Social and Communication Disorders
DORBA	Direct Observation of Repetitive Behaviours in Autism
DSM	Diagnostic and Statistical Manual
ECG	Electrocardiogram
ER	Emotion Recognition
FOS	Foundation Outcome Statement skills
FPR	Functional Performance Record
FSIQ	Full Scale Intelligence Quotient
GAS	Goal Attainment Scoring
HR	Heart Rate
HRV	Heart Rate Variability
IBI	Inter-Beat Interval
ICC	Intraclass Correlations
ID	Intellectual disability
IEP	Individualised Education Plan
IoU	Intolerance of Uncertainty
IQ	Intelligence Quotient
IRR	Inter-Rater Reliability
LED	Light-Emitting Diode
MSE	Multi-Sensory Environment
NICE	National Institute for Health and Care Excellence

NVIQ/PIQ	Non-Verbal Intelligence Quotient/Performance Intelligence Quotient
OLR	Ordinal Logistic Regression
PACT	Preschool Autism Communication Trial
PARS	Paediatric Anxiety Rating Scale
PBI	Problem Behaviour Inventory
PEERS®	Program for the Education and Enrichment of Relational Skills
POSA	Preschool Observation Scale of Anxiety
RBQ-2	Repetitive Behaviour Questionnaire-2
RBS-R	Repetitive Behaviour Scale-Revised
RMBs	Repetitive Motor Behaviours
RMSSD	Root Mean Square Successive Difference
RRBs	Restricted and Repetitive Behaviours
SAND	Sensory Assessment for Neurodevelopmental Disorders
SB	Stereotypic self-stimulatory Behaviour
SCARED	Screen for Child Anxiety Related Disorders
SCAS	Spence Children's Anxiety Scale
SCQ	Social Communication Questionnaire
SEN	Special Educational Needs
SEQ	Sensory Experiences Questionnaire
SIT	Sensory Integration Therapy
SP	Sensory Profile
SPA	Sensory Processing Assessment
TA	Thematic Analysis
ToM	Theory of Mind
VIQ	Verbal Intelligence Quotient
WASI	Wechsler Abbreviated Scale of Intelligence
WPPSI	Wechsler Preschool and Primary Scale of Intelligence

Chapter 1: General introduction

The focus of this thesis is Multi-Sensory Environment (MSE) use with autistic children. In this Chapter the characteristics of autism will be discussed, along with a review of current interventions for autistic individuals. Then the field of MSEs will be overviewed with discussion of the typical composition of MSEs, the history of how they have evolved, theories of how MSEs work, and how they are used. The qualitative and quantitative research into these MSEs will then be discussed with particular reference to research with autistic individuals. Finally, the thesis plan will be presented.

1.1 Autism Spectrum Disorder

Autism Spectrum Disorder (ASD; hereafter referred to as 'autism'[1]) is a developmental disorder that affects approximately 1-1.7% of individuals (Baxter et al., 2015; Fombonne, 2009a, 2009b), and is characterised by social and communication impairments and the presence of restricted and repetitive behaviours (RRBs), interests and activities (American Psychiatric Association, APA, 2013). The behavioural presentation and severity of symptoms varies by individual, making autism a heterogeneous disorder. Heterogeneity in autism is also influenced by variation in intelligence. Intellectual disability (ID; also known as learning disability) is characterised by an intelligence quotient (IQ) of less than 70 (APA, 2013), with the co-occurrence of autism with ID being estimated at 30-68% (Centers for Disease Control and Prevention, 2014; Chakrabarti & Fombonne, 2005; Yeargin-Allsopp et al., 2003). Intellectual functioning has also been found to negatively correlate with challenging and motor behaviours (Tureck, Matson, Cervantes, & Konst, 2014).

Particularly relevant for this thesis, sensory symptoms are suggested to be present in 42%-90% of autistic people (e.g. Baranek, David, Poe, Stone, & Watson, 2006; Ben-Sasson, Carter, & Briggs-Gowan, 2009; Kientz & Dunn, 1997; Le Couteur et al., 1989; Leekam, Nieto, Libby, Wing, & Gould, 2007; Volkmar, Cohen, & Paul, 1986; Watling, Deitz, & White, 2001). The variation in prevalence figures may relate to the heterogeneity of autism and/or different measurement (e.g. questionnaire, observation) of sensory symptoms. The DSM-V description of these sensory symptoms includes hyper-, and hypo-reactivity to sensory input, along with unusual sensory interest (APA, 2013). Hyper-reactivity is the behavioural representation of suggested internal hyper-sensitivity and includes such behaviours as covering the ears in response to an unobtrusive sound (e.g. Lane, Young, Baker, & Angley, 2010). Hypo-reactivity is the behavioural

[1] Identity first language is predominantly used in this thesis to reflect the preferences of the majority of autistic individuals surveyed by Kenny et al. (2015). However, person first language is also used on occasion to respect the preferences of others on the spectrum.

representation of suggested internal hypo-sensitivity and includes such behaviours as not reacting to pain (e.g. Lane et al., 2010). Finally, unusual sensory interest is a sensory symptom which can result in sensory seeking behaviours such as looking at stimuli from an unusual angle (e.g. Hanson et al., 2016).

1.1.1 Autism therapies and interventions

Autism affects the lives of the individual and their family (Newschaffer et al., 2007), and therefore interventions have been devised to improve sensory, cognitive and behavioural functioning. This review includes all categories of intervention recommended for autistic children by the National Institute for Health and Care Excellence (NICE, 2013), as well as other sensory, cognitive and behavioural interventions that involve one-to-one or group work with autistic individuals. However, it will not review pharmacological or dietary interventions as these are specifically not recommended for autistic children by NICE (NICE, 2013).

1.1.1.1 Sensory therapies

Sensory integration therapy (SIT, also called Ayres Sensory Integration® intervention; Ayres, 1972, 1979, 1989) has been used with autistic individuals to varying degrees of success. Within SIT, structured, repetitive exposures to sensory stimulation are intended to improve the neurological integration of the sensory input, improving responses to sensory stimuli (e.g. reduce distress) and enabling learning (e.g. social interaction). Although reportedly beneficial (for reviews see Baranek, 2002; Schoen et al., 2019), the mechanism which promotes benefits is debated (Baranek, 2002), and studies have generally been of poor quality (Schaaf et al., 2014). Additionally, some studies purporting to test the effect of SIT (e.g. Devlin, Healy, Leader, & Hughes, 2011) have been criticised for implementing a sensory intervention that does not adhere to the strict practices of this therapy (e.g. Schaaf & Blanche, 2011), drawing into question the evidence base for SIT. However, a recently reported randomised control trial into the use of SIT with autistic children is in progress and will provide valuable evidence on the efficacy of this widely used therapy (Randell et al., 2019).

More general sensory-based interventions, including auditory integration training (Berard, 1982; 1993) and music therapy (Bruscia, 1982), are suggested to reduce maladaptive, hyperactive and stereotypic behaviours, as well as improve attention (Escalona, Field, Singer-Strunck, Cullen, & Hartshorn, 2001; Field et al., 1997). A Cochrane review of music therapy also reported improved social interaction, verbal and non-verbal skills, joy, and parent-child relationships (Geretsegger, Elefant, Mössler, & Gold, 2014). However, systematic reviews of these interventions have concluded that across all studies, there is limited evidence of benefits, and larger studies are needed (Case-Smith, Weaver, & Fristad, 2015; Geretsegger et al., 2014; Sinha, Silove, Hayen, & Williams, 2011).

1.1.1.2 Applied Behavioural Analysis

Applied Behavioural Analysis (ABA) interventions use motivation and specific learning techniques to bring about socially relevant behaviour change. There are many methods of ABA interventions (Maurice, Green, & Foxx, 2001), but typically they are conducted one-to-one for 20-40 hours per week. ABA can improve intellectual and social functioning, learning of daily-life skills, and language development in autistic children (for review see Case-Smith & Arbesman, 2008; Granpeesheh, Tarbox, & Dixon, 2014; Makrygianni, Gena, Katoudi, & Galanis, 2018; Reichow, Barton, Boyd, & Hume, 2012; Virués-Ortega, 2010). Despite these positive findings, the quality of the evidence is weak due to methodological issues, in particular, non-randomised studies (e.g. Reichow et al., 2012). Additionally, ABA therapy is controversial as some suggest it is training an autistic individual to act as if they are 'neurotypical' (Baker, 2006), and it is questioned whether the outcomes, and methods of producing outcomes (i.e. 40 hours of training per week), are in the best interest of the autistic person.

1.1.1.3 Parent-directed or parent-mediated therapies

Parent-directed or parent-mediated therapies provide behaviour management techniques and education to parents of autistic individuals with the aim of improving outcomes. One example of this is the Preschool Autism Communication Trial, a form of parent-mediated social communication therapy (PACT; Aldred, Green, & Adams, 2004). Parents were trained in tailored adaptive communication techniques, which they implemented over 12 months. Findings demonstrated improvements in autistic symptoms, particularly communication and interaction, in children who received the intervention (Aldred et al., 2004), as well as long-term improvements at follow-up (Pickles et al., 2016). Further, a review of 17 studies found that these therapies can lead to a reduction in autistic symptom severity, improvement in vocabulary, parent-child synchrony and child attention (Oono, Honey, & McConachie, 2013), but they cautioned that methodological flaws inhibit definitive conclusions. Additionally, as parental motivation and availability is critical, there are limits to how widely this intervention can be implemented.

1.1.1.4 Social skills and social cognition training

Social skills training can take many different forms but generally it involves describing, modelling and practising social skills (Ozonoff & Miller, 1995). One example of this training is the Program for the Education and Enrichment of Relational Skills (PEERS®; Laugeson & Frankel, 2010), where autistic individuals take part in bi-weekly sessions of role-playing and rehearsing social skills. PEERS® was found to improve knowledge of social skills and enable some increase in friendship engagement in young autistic adults (Wyman & Claro, 2019). More broadly, social skills training has been found to improve loneliness, friendship quality and social competence in autistic young people, but not parent or child depression, or emotion recognition (for review see, Reichow, Steiner, & Volkmar, 2012). Overall, reviews conclude that there is more evidence for benefit in children than adolescents and adults (Case-Smith & Arbesman, 2008; Gillies, Carroll, & Loos, 2013).

Theory of mind (ToM) interventions have also been used with autistic individuals. ToM interventions aim to improve the difficulty that autistic people have in understanding other people's minds, emotions, feelings and beliefs (Baron-Cohen, Leslie, & Frith, 1985). For example, thought bubbles on cartoons can be used to illustrate the thoughts and beliefs of others (Parsons & Mitchell, 1999). ToM interventions have been found to improve ToM skills, general communication and social interaction (for reviews see, Fletcher-Watson, McConnell, Manola, & McConachie, 2014; Hofmann et al., 2016).

Emotion recognition (ER) training has also be used with autistic individuals (for reviews see Berggren et al., 2018; Harms, Martin, & Wallace, 2010), with the aim of training the individual to look at specific markers on the face to enable them to identify the corresponding emotions (e.g. Kuusikko et al., 2009). The ER intervention, The Transporters, which aims to teach autistic children about ER through cartoon videos, has been reported to improve ER in autistic children (Golan et al., 2009), although reviews present more variable findings (Berggren et al., 2018; Harms et al., 2010).

1.1.1.5 Cognitive Behavioural Therapy

Cognitive Behavioural Therapy (CBT) has been used with autistic individuals to improve anxiety by targeting behavioural (e.g. negative stimuli avoidance) and cognitive (e.g. distorted beliefs) symptoms that cause and reinforce anxiety. Both a systematic review and meta-analysis into the effect of CBT on autistic individuals report a reduction in anxiety (Ung, Selles, Small, & Storch, 2015; Weston, Hodgekins, & Langdon, 2016). However, Weston et al. (2016) found that self-report outcome measures indicated that CBT had limited impact, but informant-, and clinician-report measures indicated efficacy. This could relate to the difficulty that some autistic individuals have in understanding and recognising their own emotions (i.e. alexithymia; Hill, Berthoz, & Frith, 2004).

1.1.1.6 Conclusion

Many interventions have been used with autistic individuals to varying degrees of success, but heterogeneity within autism, along with methodological issues, may account for some variability in findings. Broader issues with some of these interventions are a lack of generalisability of benefits to other contexts (e.g. ER, Berggren et al., 2018; ToM, Fletcher-Watson et al., 2014; social skills training, Case-Smith & Arbesman, 2008; Gillies, Carroll, & Loos, 2013), inaccessibility for autistic individuals with lower communication and intellectual ability (e.g. CBT and social skills training), and the high costs of intensive therapy (e.g. ABA). However, MSEs are accessible to all individuals regardless of ability, and they are already widely used in special-needs schools for autistic children.

1.2 Multi-Sensory Environments

1.2.1 Definition of a Multi-Sensory Environment

MSEs (also called sensory or Snoezelen® rooms) are often considered a form of sensory intervention (e.g. Mey, Cheng, & Ching, 2015). There is general agreement that they contain equipment that provide **sensory stimulation** in any one, or all, of these domains: visual, auditory, tactile, olfactory, vestibular and proprioceptive (Fava & Strauss, 2010; Kaplan, Clopton, Kaplan, Messbauer, & McPherson, 2006). Definitions have also stated that the MSE enables both **stimulation** (e.g. Fava & Strauss, 2010) and **relaxation** (e.g. Pagliano, 1999), which appears contradictory. However, it is possible that through receiving stimulation, an individual may have their needs met and become more relaxed. Additionally, the MSE is described as an **adaptive space** as it can be **controlled** (Pagliano, 1998), therefore, it could be controlled to relax or stimulate the user depending on their individual needs.

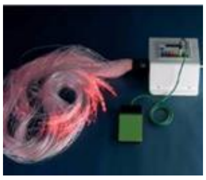
Some suggest that the MSE must be a **dedicated space** (Eijgendaal et al., 2010; Pagliano, 1998), whilst Mount & Cavet (1995) present a more flexible definition suggesting that sensory equipment in the corner of a room can be described as an MSE. However, research in this area has been exclusively conducted in dedicated MSEs, therefore, Mount and Cavet's more flexible definition has not been widely accepted within this field. Combining previous descriptors of MSEs, the following definition was created:

> An MSE is a **dedicated space** that contains **sensory equipment** to modulate the environment and provide **sensory stimulation** across **some or all sensory domains**. It is an **adaptive space** as the user or practitioner can **control** the equipment, changing the type and amount of stimulation to meet the user’s needs.

1.2.2 Typical contents

Based on previous descriptions of MSEs within the literature, MSEs typically include a bubble tube, mirror ball, projector, colour room lights, tactile board, aroma diffuser, CD player, fibre optics, bean bags and mirrors (Table 1.1).

Table 1.1. Typical equipment found in Multi-Sensory Environments (MSEs)

Item	Description
	A **bubble tube** is a cylindrical tube, usually two meters tall, filled with water. When activated, bubbles flow in a continuous upwards direction and the colour of the water can be changed using coloured lights. Primarily, the bubble tube provides visual stimulation. However, the bubble tube’s motor means it also vibrates providing tactile stimulation, and produces a humming sound providing auditory stimulation.
	A **mirror ball** (also known as a disco ball) has a light shining on it and rotates continuously. It produces multiple spots of light that cover the room and move slowly as the mirror ball rotates. The mirror ball provides visual stimulation.
	A **projector** typically shines a light through colour or picture wheels that project a rotating colour or picture onto the wall. This provides visual stimulation, and slight auditory stimulation from the sound of the wheel rotating in the projector.
	**Coloured LED room lights** are lights that can change the colour of the room, providing visual stimulation.
	**Tactile boards** are mounted on walls and have many different textures to provide tactile stimulation. However, they are often brightly coloured with high contrast and can therefore provide some visual stimulation.
	An **aroma diffuser** is used to diffuse different scents throughout the room and stimulates the olfactory sense.
	A **CD player** is used to play music, stimulating the auditory sense.
	**Fibre optics** are long, fibre optic cables that light-up. They are either mounted on the ceiling creating a curtain of fibre optic cabling, or they are on the floor (pictured). The colour of the fibre optics can be changed to stimulate the visual sense. The texture of the cables can provide tactile stimulation.
	**Bean bags** are often used for comfortable seating within the MSE. Bean bags also have a tactile quality due to the ‘beans’ inside moving when touched.
	**Mirrors** (behind the bubble tube in the picture) provide visual stimulation primarily through reflections of equipment, as well as enabling the user to look at themselves.

1.2.3 History of MSEs

The importance of sensory stimulation, and the detrimental effect of sensory deprivation, has long been acknowledged (for review see, Zubek, 1969). In the 1960s ‘sensory cafeterias’ were used for individuals with autism, ID and developmental delay to improve communication, behaviour and promote development (Cleland & Clark, 1966). Sensory cafeterias were rooms with sensory stimuli that could provide sensory stimulation across the modalities, and these are suggested to be the pre-cursor to MSEs. MSEs, which were established in the Netherlands by Jan Hulsegge and Ad Verheul (Hulsegge & Verheul, 1986), and were designed to provide relaxation and leisure opportunities for severely disabled individuals of all ages (Ayre, 1998; Hulsegge & Verheul, 1986; Hutchinson & Hagger, 1994). They were originally called Snoezelen® rooms, which described not only the room with sensory equipment but also a method of use (Fava & Strauss, 2010). Within the Snoezelen® method of use, severely disabled individuals gained a sense of well-being and relaxation through independently choosing how to use the MSE (Bozic, 1997; Hulsegge & Verheul, 1986).

MSEs were reportedly established in the UK in the late 1980s (Snoezelen, n.d.), and in North America and Canada in the early 1990s (American Association of Multi-Sensory Environments, n.d.). By the mid-1990s, literature was being published about the use of MSEs in educational settings (Bozic, 1997; Bozic & Murdoch, 1996; Hutchinson & Kewin, 1994), at which point MSEs were being used for those with ID, as well as severe mental and physical disabilities. The first research specifically on autistic individuals is in an unpublished thesis from 1998 (Germeau, 1998).

MSEs are now used internationally, including in North America (e.g. Cuvo, May, & Post, 2001), China (e.g. Chan & Chien, 2017), Australia (e.g. Stephenson & Carter, 2011), Israel (e.g. Merrick, Cahana, Lotan, Kandel, & Carmeli, 2004, who suggest there are 30 MSEs in Israel) and the UK (e.g. Bozic, 1997), yet exact figures on their prevalence are unknown. They are used with varying populations including those with dementia (for review see, Strom, Ytrehus, & Grov, 2016), severe and complex disabilities (e.g. Glenn, Cunningham, & Shorrock, 1996), and brain injury (e.g. Hotz et al., 2006). They are widely used in the special-educational needs sector, where MSEs play substantial roles in statutory special education plans and curricula (Botts, Hershfeldt, & Christensen-Sandfort, 2008; Carter & Stephenson, 2012; Fowler, 2008; Hogg, Cavet, Lambe, & Smeddle, 2001).

1.2.4 Uses of MSEs

In one Australian school, Pagliano (1998) interviewed 14 practitioners who described the MSE as having multiple uses including leisure, education and therapy. Pagliano labelled the MSE an ‘open-minded’ space and described how the multiple uses enable many needs to be met.

Aligning with this, Carter and Stephenson (2012) found that 86% of 19 practitioners from Australian schools believed the MSE could be used for both leisure and education. Ayre (1998), who interviewed teams of practitioners across five settings, found that MSEs were used in different ways in different settings. In residential settings and hospitals they were used for relaxation and leisure, and in school settings they were used to promote child development, and education.

Bozic (1997), interviewing 20 practitioners across four UK schools, provides more detailed information about how MSEs are used in educational settings. He identified that the practitioners endorsed two distinct approaches, or 'repertoires', of MSE use, 'child-led' and 'developmental'. For the child-led repertoire, it was suggested that maximum benefit was gained when the child leads themselves in MSE exploration and relaxation. Whereas, for the developmental repertoire, MSE use was described as most beneficial when the teacher guided the pupil, and both were active in the child's development. Stephenson & Carter (2011a) found this same distinction in their sample of five teachers, with some describing the MSE as beneficial when it was child-led and the teacher played no role, and others describing that active teaching is necessary for benefits.

The child having control of the MSE is also described as a method of use in the literature, with some practitioners suggesting that it enables positive outcomes (Stephenson & Carter, 2011a). Indeed, 73.7% of the 19 practitioners surveyed by Carter and Stephenson (2012) endorsed the benefit of this method of use. Ayre's (1998) participants not only described the benefit of giving the child control, but some participants also suggested that it could lead to the generalisation of these skills to other environments (e.g. computer switches or domestic environment switches).

The child-led and teacher-led (i.e. developmental repertoire) approaches are mutually exclusive. However, the child being in control is compatible with both methods of use in that the child could be in control of the equipment whilst either they (i.e. child-led approach) or the teacher (i.e. teacher-led approach) decides the equipment to be used and how to use it.

Indeed, there is also a small amount of evidence from the quantitative literature that how the MSE is used affects outcomes. For example, Fava and Strauss (2010) reported that when MSE use was child-led, stereotyped behaviour reduced in their autistic and ID adult participants, compared to when the MSE was used in a structured way. However, there is more equivocal evidence that caregiver attention within the MSE can affect outcomes (Glenn et al., 1996; Hill, Trusler, Furniss, & Lancioni, 2012).

As MSEs are widely used by autistic children, investigations into factors that affect outcomes within this sample will not only provide necessary insight into theoretical underpinnings for the use of MSEs, but also could provide practitioners with guidance on best methods of use with this sample.

1.2.5 Theories of action

A range of theories attempting to explain the effect of the MSE have been proposed and are reviewed below, although note that none have been empirically tested.

Sensory stimulation

A dominant and intuitive theory suggests that MSEs are beneficial because they provide sensory stimulation (Baillon et al. 2002; Chan, Fung, Tong, & Thompson, 2005; Chan et al., 2010; Eijgendaal et al., 2010; Hutchinson & Hagger, 1994; Mey, Cheng, & Ching, 2015; Moore, Harris, & Stephens, 1994). Baillon et al. (2002) discusses that individuals with severe disabilities have limited opportunities for sensory stimulation in every-day life, and this can lead to psychological and behavioural problems. Proponents of this theory claim that by meeting the user's sensory needs, the MSE is able to bring about positive behavioural outcomes (e.g. Baillon et al. 2002). Mey et al. (2015) suggest that the unusual sensory profiles of autistic individuals (e.g. Green, Chandler, Charman, Simonoff, & Baird, 2016; Kern et al., 2007) may explain why MSEs can bring them benefits. However, this theory is not well specified and does not explain *why* sensory stimulation may improve outcomes.

Baillon et al. (2002) proposes an extension to this theory that is more specific. They suggest that for individuals with disabilities multiple sources of stimulation in the every-day environment can be overwhelming and make processing information difficult. The MSE removes extraneous sensory information such that the sensory stimulation provided in the MSE is more interpretable. This improves the processing and integration of sensory information.

Botts et al. (2008) draws on sensory integration theory (Ayres, 1979) to explain the mechanism of change in MSEs. According to sensory integration theory, experiencing different sensory stimulation can enable the reorganisation of neural networks, enabling better processing and integration of sensory information and improved behaviour. MSE use could therefore provide the necessary sensory stimulation for neural reorganisation, and consequently enable behavioural and learning improvements. However, sensory integration theory has been criticised for being based on outdated assumptions (Baranek, 2002) and lacking empirical support (e.g. Dawson & Watling, 2000), and Botts et al.'s theory is similarly under-specified.

Demand-free space, learned helplessness and control

Baillon et al. (2002), supported by Eijgendaal et al. (2010), propose that the MSE is 'demand-free' as it does not demand any cognitive or attentional processing by the user for the

MSE to work. This can alleviate stress and encourage engagement. However, many benefits other than stress reduction and engagement have been reported from MSE use, such as reduced stereotypic behaviour (Cuvo et al., 2001), and it is not clear how this theory could explain those benefits. Additionally, autistic people commonly experience a need for order and routine (APA, 2013), and therefore, may prefer a structured setting over a freer environment. As such, this theory may be less applicable to autistic users.

For people with ID, many daily-life tasks are performed by others (e.g. carers) which can lead to feelings of helplessness and a fear of failure (i.e. 'learned helplessness', Maier & Seligman, 1976). The therapeutic benefit of the MSE is argued to be its quality of being a ‘failure-free setting’, where the user can exert control on their surroundings, gaining awareness of their own contingency, and reducing learned helplessness (described in Baillon et al., 2002). It is also suggested that learning contingency can reduce learned helplessness in settings outside the MSE as the user feels capable of enacting change on their environment (Eijgendaal et al., 2010; Glenn et al., 1996; Hirstwood & Smith, 1996; Moore et al., 1994). However, this theory is limited as it assumes poor adaptive functioning and related feelings of learned helplessness in MSE users.

Others have theorised that for individuals with disabilities the everyday environment can be unpredictable and chaotic (e.g. Eijgendaal et al., 2010), and as the MSE allows for the sensory environment to be controlled, it becomes predictable and benefits ensue (Eijgendaal et al., 2010; Fowler, 2008; Hirstwood & Smith, 1996). This theory may be particularly relevant to autistic people as qualitative studies have found that uncontrollable sensory stimuli (e.g. room lights in a shared space, unexpected physical contact, loud music) are unpleasant and can be distressing (Ashburner, Bennett, Rodger, & Ziviani, 2013; Dickie, Watson, McComish, Schultz, & Baranek, 2009; Robertson & Simmons, 2015). In contrast, controllable stimuli (e.g. controllable room lights or music volume) are perceived as pleasant, bringing enjoyment and reducing stress (Robertson & Simmons, 2015).

MSEs can meet some of the issues associated with other autism therapies and interventions, including accessibility for those with lower intellectual ability (e.g. being 'demand-free', Eijgendaal et al., 2010). Notably, none of the theories are autism specific. Considering the unusual sensory profiles (APA, 2013) and the reported preference for control (e.g. Robertson & Simmons, 2015), both the sensory stimulation (e.g. Baillon et al. 2002) and control (e.g. Eijgendaal et al. 2010) MSE theories may predict why MSEs enable benefits for autistic individuals.

1.3 Evidence for the effect of MSE use

Considering the wide use of MSEs in special-needs schools, this thesis explores MSE use for autistic individuals, particularly autistic children. However, there are only six MSE studies that have included children, with only one study on autistic children. Therefore, the review of the evidence-base has been broadened to include studies with ID individuals, many of whom will have autism (e.g. Chakrabarti & Fombonne, 2005), and include participants across the lifespan.

1.3.1 Qualitative and survey findings

Practitioners who support users in the MSE can provide in-depth insight into the most effective uses and outcomes of MSEs. Practitioners interviewed by Stephenson and Carter (2011b) from one school emphasised the stimulation the MSE could provide, while the other school emphasised relaxation, with both schools describing enjoyment as an outcome from MSE use. Bozic's (1997) participants described enjoyment as an outcome from the aforementioned child-led approach and learning as an outcome from the developmental approach. Similarly, Ayre's (1998) participants also highlighted learning, enjoyment and relaxation as outcomes from MSE use. However, Stephenson and Carter's (2011a) participants described a wider range of benefits including: learning (i.e. skill development), relaxation, enjoyment, attention, building relationships, and reducing anxiety. Building on their previous qualitative work (Stephenson & Carter 2011a, b), Carter and Stephenson (2012) devised a survey asking practitioners to select benefits of MSE use from a list of previously described benefits. Four of the most endorsed outcomes included relaxation (89.5%), focus (73.7%), visual skills (68.4%), and improvement in challenging behaviour (68.4%). Items endorsed by around half of the sample included building relationships, reduction in self-stimulatory behaviour, and cognitive skills. Four of the least well endorsed items related to outcomes continuing after the MSE session.

These findings suggest that practitioners working with children with a range of disabilities believe there are a variety of benefits that are possible from MSE use. Notably, there was low endorsement that benefits persisted beyond the MSE. These findings, although valuable for their real-world insight, are the opinions of practitioners and therefore, are subject to bias.

1.3.2 Quantitative findings

Previous studies measuring the effect of the MSE on varying outcomes were reviewed. This review includes studies that are published in English and conducted on those with disabilities of all ages. Maximum effort was made to obtain all relevant articles, including through the British Library, and contacting authors. The studies included within this review are summarised in Table 1.2. How the MSE was used by the participants is largely unspecified but where it is specified, it is included in the table (e.g. Fava & Strauss, stimulus preference versus Snoezelen).

Previous reviews of MSE studies have commented on the poor quality of research including the lack of scientific rigour, small sample sizes and diagnostic heterogeneity (Botts et al., 2008; Chan et al., 2010; Hogg et al., 2001; Lai, 2003; Lotan & Gold, 2009). Many also state that it is hard to draw conclusions across studies due to different outcome measures (Chan et al., 2010; Lai, 2003), different participant groups (Chan et al., 2010; Hogg et al., 2001; Lai, 2003), and different methodologies (Hogg et al., 2001; Lotan & Gold, 2009). Botts et al. (2008) therefore concludes that MSEs do not meet the necessary standards for evidence-based practice and Lotan and Gold (2009) state that the MSE cannot be validated as a therapeutic intervention. Therefore, all five reviews have called for more research, with improved scientific rigor.

As there is wide variation in methodological approaches, comparisons of these approaches are provided below. Following this there is a summary of the outcome measures used by each study within Table 1.2 and an overview of the findings for each outcome measure.

Methodological approaches

Samples

Total sample sizes (collapsed across groups and conditions) vary greatly across the studies in this field (n=2-89, M=19.56, SD=23.12, *median*=8), with nine out of the 17 studies containing 8 or fewer participants, and the remaining 8 studies containing 17-89 participants. Age of the samples also vary widely across studies with participants aged 4-71 years. Out of the 17 studies, five studied children, 10 studied adults, and 2 studied both children and adults. Neither studies on children nor adult participants appear to have more positive findings, but the variety in outcomes and study design makes comparison difficult.

Heterogeneity of diagnoses both within and between studies also affects generalisability and comparability of studies, as does the use of participant groups with multiple diagnoses (e.g. Houghton et al., 1998). However, adequate sample size and repeated measures design can limit some of these issues (see Chan & Chien, 2017 for a good example of this). A particular impediment to comparison is that some studies (e.g. Martin et al., 1998) mention whether specific behaviours of interest were present in their sample (e.g. challenging behaviours), whereas other studies with similar participants do not disclose this information (e.g. Glenn et al., 1996). Another issue is the degree of specificity, particularly the measurement of challenging behaviours (e.g. Chan & Chien, 2017) compared to stereotyped behaviours (Hill et al., 2012), which is sometimes considered as a specific type of challenging behaviour.

Of particular relevance to this thesis, there has been far more investigation of the impact of MSEs on those with multiple disabilities than on autistic individuals (i.e. 5/17 studies on autistic samples), and the sample sizes are generally inadequate, or methodological issues affect conclusions being drawn. Owing to sensory profile differences within autism (APA, 2013) and between those with autism and those with other disabilities (e.g. Green et al., 2016), the impact of MSEs on an autistic population may be distinct to those without autism.

Table 1.2. Studies investigating Multi-Sensory Environment (MSE) use with disabled individuals divided by participant age group

Authors	Participants	Measurement time points	Design	Outcome measures	Number x duration MSE session	Staff: Participant ratio	Key findings
Adult participants							
Ashby, Broxholme, Pitcaithly, & Lindsay (1995) §	**Profound multiple handicaps and profound ID** *n*=8 23-62 years	Pre-, mid-, and post-MSE intervention	*Case studies*	• Observation of concentration, responsiveness and therapeutic value	20 x 20 mins	Not stated	• Improved concentration and responsiveness in 6 participants • Two therapists highly rated the sessions therapeutic value
Chan & Chien (2017)	**Severe and profound ID with challenging behaviour** *n*=42 18-64 years	Pre-, and post-MSE intervention (immediately after the 10-week intervention)	*Between groups:* MSE, massage therapy, MSE with massage therapy, and control condition	*Post-intervention:* • Challenging behaviour (BPI-01) • Maladaptive (including stereotypic behaviours) and adaptive behaviour (BC) • Heart & respiration rate • Alertness (AOC)	20 x 20-30 mins (over 10 weeks)	1:1	• No significant difference between the 4 groups in frequency or severity of challenging behaviours, heart rate, respiration rate, maladaptive (including stereotypic behaviours) or adaptive behaviours at post-intervention • Significant decrease in alertness of all 4 groups compared to pre-intervention
Cuvo et al. (2001) ++	**Profound ID** *n*=3 44-65 years	Pre-, mid-, post-MSE sessions	*Repeated measures:* Living room (control), outside (comparison) & MSE sessions	• Observations of stereotypic behaviour and engagement	Not stated	Living room 1:6, outdoor activity 1:1 & MSE 1:1	• MSE > living room: Reduction in stereotypical behaviour & increase in engagement • Outdoor activity > MSE & living room: Reduction in stereotypical behaviours and increasing engagement

Fava & Strauss (2010)	**Profound ID & autism** *n*=27 (of these autism *n*=9) 30-48 years	Baseline, pre-, mid-, post-session (immediately after MSE or stimulus preference) and post-baseline	*Between groups and conditions:* Living room (control), MSE stimulus preference & MSE Snoezelen condition[‡]	• Observation of challenging (including, aggression and stereotypical behaviours) and pro-social behaviour	20 x 25 mins (3 x per week for 7 weeks)	Living room 3:5 & MSE 1:1	• Reduction in challenging behaviours in the autism group who took part in the MSE Snoezelen intervention (*n*=3), compared to other participants in other conditions (i.e. MSE stimulus preference intervention and living room) • Reduction in stereotyped behaviours in autism and ID group who took part in the MSE Snoezelen intervention, compared to other participants in other conditions (i.e. MSE stimulus preference intervention and living room) • Increase in prosocial behaviours only in profound ID group who took part in the MSE stimulus preference condition
Kaplan et al. (2006)[++]	**Moderate/severe ID also with autism and challenging behaviour** *n*=3 31-52 years	Experiment 1: Post-session (for 5 minutes after) Experiment 2: Baseline & post-session (days and week after)	*ABA design:* Occupational therapy treatment in MSE & non-MSE (control)	*Experiment 1:* • Engagement in specific functional task for each participant *Experiment 2:* • Frequency of challenging behaviours	Twice per week x 30 mins (number of weeks not stated)	Control 1:1 & MSE 1:1	• For 2 out of 3 participants, MSE sessions lead to improvements in engagement and reductions in challenging behaviours
Lindsay et al. (1997)[§]	**Profound ID with challenging behaviour** *n=8* 23-62 years	Baseline, and then after 10, 15 & 20 sessions	*Repeated measures:* Relaxation therapy, Hand massage/aroma therapy, active therapy & MSE	• Observations of engagement, relaxation and enjoyment	20 x 20 mins (for each therapy)	Not stated	• No change in relaxation across therapies • MSE and relaxation therapy: - most positive effect on concentration - deemed the most 'enjoyable' • Active therapy and hand-massage/aromatherapy: - no or negative effect on concentration - deemed less 'enjoyable'

Lindsay, Black, & Hornsby (2001)[§]	**Profound ID with challenging behaviour** *n*=8 23-62 years	Baseline, and then after 5, 10, 15 & 20 sessions	*Repeated measures:* Relaxation therapy, hand massage/aroma therapy, active therapy & MSE	• Observations of communication[^^^] and negative communication (akin to challenging behaviours)	20 x 20 mins (for each therapy)	Not stated	• MSE and relaxation therapy: - increased communication - decreased some negative communication • Active therapy and hand-massage/aroma therapy: - no effect on communication
Martin, Gaffan, & Williams (1998)	**Severe/profound ID with challenging behaviour** *n*=27 22-61 years	Baseline, pre-, and post-session for all MSE and control sessions	*ABA design with 2 groups:* MSE & control: "non-complex sensory environment" p. 69	• Observation of engagment, relaxation, challenging and stereotypic behaviour • Standardised assessments: FPR & PBI	32 x 60 mins	Either 1:3, 1:4 & 1:5, depending on group size[*]	• No difference in observation of engagement, relaxation, challenging or stereotypic behaviour in the MSE compared to control • Objective measures (FPR and PBI) demonstrated no difference between MSE and control conditions
McKee, Harris, Rice, & Silk (2007)	**Autism** *n*=3 28-32 years	Baseline & during MSE	*ABAB design:* Baseline (behavioural measurement for 27 days) & MSE	• Observation of challenging & pro-social behaviours - specific to each participant	(Not explicitly stated, although maximum possible 15 x 45 mins)	MSE 1:1	• No participant showed a reduction in challenging behaviours when comparing MSE to baseline • One participant had increased challenging behaviours during MSE • Tendency for participants to engage in more prosocial behaviours in MSE
Singh et al. (2004)[^^]	**Severe or profound ID and mental illness** *n*=45 22-57 years	Pre-, within and post-session	*Repeated measures:* Activities of Daily Living (ADL), vocational skills training & MSE	• Observation challenging behaviours (aggression & self-injury)	50 x 60 mins (per condition over 10 weeks)	Not stated	• Self-injuring and aggression were lowest in MSE compared to other conditions

			Child participants				
Glenn et al. (1996)[++]	**Profound and multiple ID** *n*=5 4-14 years	Throughout all sessions	*Between participants:* MSE session with or without social interaction from family member	• Observation of object interaction, emotional state, stereotypic and pro-social behaviour	Between 3-5 x 40 mins	MSE social condition 1:1 & MSE no social condition child alone	• Improved positive emotions, pro-social behaviours and less stereotypical behaviours during the social interaction condition • No comment on object interaction between conditions
Hill, Trusler, Furniss, & Lancioni (2012)	**Severe ID with stereotyped behaviour** *n=2* 14 & 18 years	Throughout all sessions	*Repeated measures:* MSE & living room, both with low level of carer attention & high level of carer attention	• Observation of engagment and stereotypical behaviour	10 x 30 mins (over 10 weeks)	1:1	• Significantly lower stereotypical behaviours in the MSE compared to living room, irrespective of carer attention level • Significantly higher engagment in both the MSE and living room in the high carer attention condition
Houghton et al. (1998)	**Severe disability** including severe ID, and severe ID with either autism, visual impairment, or hearing impairment, and multiple disabilities with and without visual impairment *n*= 17 5-18 years	Pre-, and post-MSE intervention	*Repeated measures:* Classroom, trip to farm & MSE session	• FOS skills	Varied by participant x 30-40 mins (over 4 weeks)	Not stated for classroom or farm trip & MSE 1:1	• A significant increase in the number of FOS skills after the MSE intervention, compared to FOS skills before the MSE intervention • Descriptive statistics suggested FOS skills extended to other settings, for example, farm trip

Mey et al. (2015)++	**Autism** *n*=6 5-8 years	Post-MSE sessions (parent rated) & 3 timepoints throughout the year (teacher rated)	MSE curriculum across 1 year	• Observation by parent & interviews with teacher (not stated specifically which behaviours each measured): sensory functioning, learning, relationship with the facilitator, concentration, adaptive behaviour and relaxation	24 x 60 mins (over 1 year)	2:1	• Improvement in sensory functioning, learning, relationship with the facilitator, concentration, adaptive behaviour and relaxation - across all participants
Shapiro, Parush, Green, & Roth (1997)	**Moderate or severe ID and stereotypic behaviours** *n*=20 5-10 years	Pre-, within and post-session	*Repeated measures:* Playroom (control) & MSE sessions	• Heart-rate • Observation of adaptive & stereotypic behaviours	2 x 20 mins	Not stated	• Reduction in frequency and duration of stereotypic behaviours in MSE condition • Increase in frequency and duration of adaptive behaviours in MSE condition • Change in heart rate within- and post-MSE session (yet direction of change is unknown) • Analysis of data by individual revealed a regulatory effect of MSE on heart rate

Both adult and child participants							
Chan et al. (2005)+	**ID with aggression and maladaptive behaviours** *n*=89 11-71 years	Pre-intervention, mid-intervention (6 weeks), and post-intervention (12, 17, 29 weeks)	*Between groups:* Standardised activity sessions (control) & MSE sessions *Within groups:* Across 5 time-points (pre-, mid-, post-1, post-2, post-3 intervention)	*Pre-, and mid-intervention:* • Level of relaxation (BRS) • Heart rate • Emotional state diary card *Long-term effects (post-intervention 1, 2, & 3):* • Challenging behaviour (CAB) & maladaptive (including stereotypic behaviours) and adaptive behaviour (BC)	36 x 60 mins (over 12 weeks)	Not stated for control condition & 1:5/6 MSE	<u>*Immediately after intervention:*</u> *Within the MSE group:* • Significant reduction in negative and neutral moods • Significant improvement in relaxation level • Significant increase in positive mood • No significant change in heart rate *Between MSE and activity group:* • No significant difference between groups in positive, negative, or neutral mood, relaxation level or heart rate <u>*Long-term effects:*</u> *Within the MSE group:* • No **overall** reduction in challenging behaviours across time-points • Significant reduction in challenging behaviours between mid-, and post-MSE 1 (12 weeks - directly after the intervention finished), and between post-MSE 2 (17 weeks), and post-MSE 3 (29 weeks) *Between MSE and activity group:* • No difference in challenging, stereotypic, or adaptive behaviours over any time-points
Novakovic, Milovancevic, Dejanovic, & Aleksic, (2019) ^^	**Autism with ID** *n*=40 15-35 years	Pre-intervention and post-intervention (after 12 weeks of MSE use)	*Between groups:* receive MSE sessions & do not receive MSE sessions (sample randomly divided into two groups)	*Pre-, and post-intervention:* • Childhood Autism Rating Scale (CARS)	36 x 30 mins (over 12 weeks)	Not stated for non-MSE group & 1:3 MSE	<u>*After 12-week intervention:*</u> • Significant decrease in autism severity (CARS score) in those who received the MSE intervention

BRS, Behavioural Relaxation Scale (Schilling & Poppen, 1983); **CAB**, Checklist of Challenging Behaviour (R. Harris, Humphreys, & Thompson, 1994); **BC**, Behaviour Checklist (Shapiro et al., 1997); **BPI-01**, Behaviour Problem Inventory (Rojahn, Matson, Lott, Esbensen, & Smalls, 2001); **AOC**, Alertness Observation Checklist (Munde, Vlaskamp, Ruijssenaars, & Nakken, 2011); **FOS skills**, Foundation Outcome Statement skills (unpublished - produced by Education Department of Western Australia and Education Support Principals Association); **FPR**, Functional Performance Record (Mulhall, 1989); PBI, Problem Behaviour Inventory (Willis & La Vigna, 1991); **ID,** Intellectual Disability; **CARS**, Childhood Autism Rating Scale (Schopler, Reichler, & DeVellis, 1980).

[§] Ashby et al. (1995), Lindsay et al. (1997), and Lindsay et al. (2001) all tested the same participants; [++] No statistics: descriptive data only; [‡] MSE stimulus preference condition involved the participants only engaging with pre-selected equipment that they had previously indicated they most preferred. Whereas, the MSE Snoezelen condition involved the participants engaging with any equipment in the room freely; [*] The sample of 27 participants were split into groups of 3, 4, or 5 and then allocated to either group 1 or group 2; [^^] All participants were on medication and/or were undergoing different behavioural interventions throughout; [+] Although participants had developmental disorders most also had schizophrenia and were taking various medications. [^^^] Inspection of the codes included in their ‘communication’ assessment suggests that they are not specifically measuring communication, but a range of different outcomes (e.g. self-injury).

Study design and analysis

Ten of the 17 studies had control conditions (e.g. a 'non-sensory' room such as a living room, or an activity session) or compared different therapies to MSE use (e.g. massage therapy or relaxation therapy). Three studies compared different types of MSE use (e.g. MSE use with or without social interaction), and one study compared two groups, only one of which used the MSE. The other three studies had no comparison group or condition but measured the effect of the MSE over time. Broadly speaking, the studies with no comparison had more positive findings than others (Hogg et al., 2001).

Some studies did not control the level of staff engagement across different conditions. For example, Cuvo et al. (2001) found that both an MSE and an outdoor activity had more positive effects on adults with profound ID than being in a living room. However, the living room condition had a 6:1 participant to staff ratio, compared to 1:1 in the other conditions. Seven out of the 17 studies do not include complete information on participant-staff ratios, which limits interpretation of the findings.

The final consideration is the analyses used as four were descriptive only (Cuvo et al. 2001; Glenn et al. 1996; Kaplan et al. 2006; Mey et al. 2015) and six ran statistical analyses with inadequate sample sizes (Ashby et al. 1995, n=8; Lindsay et al. 1997, 2001, n=8; McKee et al. 2007, n=3; Hill et al. 2012, n=2; Fava & Strauss, 2010, n=27 was divided into three independent diagnosis groups and three independent conditions, therefore, n=3 per cell in an ANOVA). Only the remaining seven studies were able to provide statistical evidence.

Outcomes of quantitative studies of MSE use

A variety of outcomes have been tested in MSE studies, but there is limited justification or discussion about how these outcomes were chosen. An additional issue is that the same outcomes are measured differently across studies (see Table 1.3), and this makes drawing conclusions difficult.

Table 1.3. Outcomes and the associated measures used in previous Multi-Sensory Environment (MSE) research

Authors	Measures
	Adaptive and pro-social behaviour
Chan et al. (2005)	Adaptive behaviour: Behaviour Checklist (Shapiro et al., 1997): coding looking in the mirror, explores, initiates contact, chooses activity, smiles, laughs and verbalises
Chan et al. (2017)	Adaptive behaviour: Behaviour Checklist (Shapiro et al., 1997): coding looking in the mirror, explores, initiates contact, chooses activity, smiles, laughs and verbalises
Fava et al. (2010)	Pro-social behaviour: Frequency of behaviours was coded including, glances, smiles, body and arm movements, approaching behaviours to caregiver, and request of physical contact
Glenn et al. (1996)	Pro-social behaviour: Frequency of behaviours was coded including, looking at person or another participant, listen to another (usually indicate by stilling and orienting), touch another, respond to another's initiation and initiate interaction

Mey et al. (2015)	Participant-specific changes in pro-social behaviour: Social issues were coded (criteria for observation not described). Three raters (parent, teacher, facilitator)
McKee et al. (2007)	Pro-social behaviour: Individually defined for each participant including, speaking slowly enough to be understood, assisting staff with a task, using words to communicate, shaking hands or high-five and making eye contact when speaking
Shapiro et al. (1997)	Adaptive behaviour: Behaviour Checklist (Shapiro et al., 1997): coding looking in the mirror, explores, initiates contact, chooses activity, smiles, laughs and verbalises
Lindsay et al. (2001)	Adaptive behaviour: Frequency of behaviours was coded including, friendly vocalisation, soft touch, non-threatening gaze, laughter and overall positive responsiveness
Alertness and responsiveness	
Ashby et al. (1995)	Responsivity scale of 0-4 (0 = no response, 4 = very responsive)
Chan et al. (2017)	Alertness Observation Checklist (Munde, 2011)
Autism severity	
Novakovic et al. (2019)	Childhood Autism Rating Scale (CARS, Schopler et al. 1980): assessment of overall autism severity through 5-10 min observation
Challenging behaviour	
Chan et al. (2005)	Checklist of Challenging Behaviour (Harris, Humphreys & Thompson, 1994, adapted by To & Chan, 1999)
Chan et al. (2017)	Behaviour Problem Inventory (Rojahn et al. 2001)
Fava et al. (2010)	Frequency of behaviours was coded including, hitting, overturning furniture, banging head, spitting and threatening
Kaplan et al. (2006)	Individually defined for each participant: participant 1 - frequency of tantrums per day, participant 2 - frequency of crying incidents per day, participant 3 - frequency of biting incidents per day
Lindsay et al. (2001)	Frequency of behaviours was coded including, screaming, self-injury, aggression to others, pulling away or leaving, and overall negative responsiveness
Martin et al. (1998)	Problem Behaviour Inventory (Willis & LaVigna, 1991), and observation of challenging behaviour individually defined for each participant
McKee et al. (2007)	Individually defined for each participant including, hitting, overturning furniture, hitting window, banging head, spitting, hitting fish tank, throwing objects and threatening
Singh et al. (2004)	Frequency of behaviours was coded including, kicking, punching, hitting, slapping, biting or slapping oneself, and head banging
Emotional state	
Chan et al. (2005)	Snoezelen diary card - researcher qualitatively noted participant emotional state (i.e. happy, neutral, agitated, relaxed and depressed)
Glenn et al. (1996)	Frequency of negative emotional state including, crying, moaning and unhappy noises, and positive emotional state including, smiling and happy noises, was coded
Engagment and concentration	
Ashby et al. (1995)	Concentration was measured as the frequency of meaningful movements demonstrating an attempt to engage in a 5 min task
Cuvo et al. (2001)	Defined separately for MSE and for living room. Within the MSE frequency of looking at visual stimuli, complying with staff requests, and touching manipulative items was included. Within the living room frequency of watching TV, complying with requests made by staff, and playing with puzzles or board games were included

Hill et al. (2012)	Defined separately for MSE and for living room. Within the MSE frequency of looking at visual stimuli, turning head to visual stimuli or noise, and touching manipulative items was included. Within living room watching TV, playing with puzzles and looking at books was included
Kaplan et al. (2006)	Individually defined for each participant: for 2 out of 3 participants it was the frequency of prompts required to complete a task, for the other participant it was the frequency they initiated throwing a ball to a member of staff
Lindsay et al. (1997)	Participants engaged in a 5-minute task. Concentration was measured as the frequency of meaningful movements demonstrating an attempt to engage in the task
Martin et al. (1998)	Frequency of behaviours including, physical contact to an object related to engagement in task (task not described), or another person
Mey et al. (2015)	Participant-specific changes to the participant's attention (criteria for observation not described). Three raters (parent, teacher, facilitator)
Enjoyment	
Lindsay et al. (1997)	Behaviour observed and rated 0-4, from least to most enjoyment (criteria for each rating not described)
Heart rate	
Chan et al. (2005)	Not stated
Chan et al. (2017)	Physiologic monitor
Shapiro et al. (1997)	Holter ECG monitor mounted in a vest
Learning	
Mey et al. (2015)	Participant-specific achievement of learning goals (criteria for observation not described). Three raters (parent, teacher, facilitator)
Houghton et al. (1998)	Foundation Outcome Statement skills, in five learning areas: display an awareness of self and body parts, social interaction, manipulation of objects and equipment, responding to information presented, communicate to express meaning, and exploration of a variety of stimuli
Object interaction	
Glenn et al. (1996)	Frequency of behaviours was coded including, looking at object, touching object and moving object as part of activity
Relationship with facilitator	
Mey et al. (2015)	Participant-specific changes in the participant's relationship with their facilitator (criteria for observation not described). Three raters (parent, teacher, facilitator)
Relaxation	
Chan et al. (2005)	Behavioural Relaxation Scale (Schilling & Poppen, 1983)
Lindsay et al. (1997)	Behaviour observed and rated 0-4, from least to most relaxation (criteria for each rating not described)
Martin et al. (1998)	Not stated
Mey et al. (2015)	Participant-specific changes in relaxation (criteria for observation not described). Three raters (parent, teacher, facilitator)

Sensory functioning	
Mey et al. (2015)	Participant-specific changes in sensory functioning (criteria for observation not described). Three raters (parent, teacher, facilitator)
Stereotypic self-stimulatory behaviour	
Chan et al. (2005)	Behaviour Checklist (Shapiro et al., 1997) containing 16 behaviours including (but not limited to), flaps hands, twirls, twiddles, rings, and flaps legs
Chan et al. (2017)	Behaviour Checklist (Shapiro et al., 1997) containing 16 behaviours including (but not limited to), flaps hands, twirls, twiddles, rings, and flaps legs
Cuvo et al. (2001)	Individually defined for each participant including, body rocking, body swaying, picking, mouthing of hand or object or placement of an object in mouth
Fava et al. (2010)	Frequency of behaviours was coded including, body rocking, body swaying, picking, mouthing of hand or object and vocal behaviours
Glenn et al. (1996)	Frequency of behaviours was coded including any behaviour directed to own body stimulation (not defined further)
Hill et al. (2012)	Frequency of behaviours was coded including, body rocking, body swaying, body jerking, picking, repetitively playing with saliva or objects with the hand, twiddling fingers, mouthing of hand or object, flapping hand or object, pacing and tapping
Martin et al. (1998)	Frequency of behaviours including, repetitive body movements or repetitive manipulation of objects (not defined further)
Shapiro et al. (1997)	Behaviour Checklist (Shapiro et al., 1997) containing 16 behaviours including (but not limited to), flaps hands, twirls, twiddles, rings, and flaps legs

N.B. The Behaviour Checklist (Shapiro et al. 1997) contains two sub-scales, adaptive and stereotypic self-stimulatory behaviour.

Drawing from Table 1.2 and 1.3, the findings of each study will be discussed by outcome measure. Outcomes for which there is more evidence will be considered first (i.e. more than two studies investigated it).

Challenging behaviour

Broadly speaking, challenging behaviours (CBs) are defined as behaviours that could potentially affect the physical safety of the individual performing the behaviour or others around them (Emerson, 1995), and can include aggressive, self-injurious, and destructive (e.g. throwing objects) behaviours. CBs are one of the most investigated outcomes in MSE studies with eight studies investigating CBs, seven with adult participants (Chan & Chien, 2017; Fava & Strauss, 2010; Kaplan et al., 2006; Lindsay et al., 2001; Martin et al., 1998; McKee et al., 2007; Singh et al., 2004), and one with both child and adult participants (Chan et al., 2005). Five of the eight studies included those with ID, and the other three studies included autistic participants. Of the five studies with ID participants, three found no improvement in CBs (Chan & Chien, 2017; Chan et al., 2005; Martin et al., 1998). However, Singh et al. (2004) found a reduction in CBs when comparing MSE use to two control conditions (activities of daily living and vocational skills training). Lindsay et al. (2001) found a reduction in CBs in their MSE condition, but CBs also reduced in a relaxation condition, which suggests the MSE effects were not specific.

The other three studies investigating CBs included autistic adult participants. Two found a mean reduction in CBs (Fava & Strauss, 2010; Kaplan et al., 2006), while the other found no difference for two of their participants and an increase in CBs for the other participant (McKee et al., 2007). Even though there is evidence that MSE use can reduce CBs in autistic adults, these studies had the smallest sample sizes of the eight reviewed (McKee et al., 2007, *n*=3; Kaplan et al., 2006, *n*=3; Fava et al., 2010, *n*=27 with *n*=9 having autism) and their results should, therefore, be interpreted with caution. Interestingly, the studies that found no effect of MSE use on CBs had the largest samples and also used published CB measures (Chan et al. 2005; Chan & Chien 2017; Martin et al. 1998).

Taken together, there is mixed evidence that MSEs can reduce CBs in individuals with autism and/or ID. The quality of the studies, particularly sample size, suggests caution should be taken in interpreting the results.

Stereotypic self-stimulatory behaviour

Sometimes considered as a type of challenging behaviour, stereotypic self-stimulatory behaviour (hereafter stereotyped behaviour) refers to repetitive body movement or object engagement. Three out of the eight studies measuring stereotyped behaviour (Shapiro et al. 1997; Chan et al. 2005; Chan & Chien 2017) used the Behaviour Checklist (BC) which was designed by Shapiro et al. (1997) for their MSE study, and then later used in other studies. Items from the stereotypic self-stimulatory sub-scale of the BC include flaps hands, twirls, and flaps legs. The other five studies created their own stereotyped behaviour measures (see Table 1.3). The majority of studies found a reduction in stereotyped behaviour from MSE use in their child and adult participants with autism or ID (Cuvo et al., 2001; Fava & Strauss, 2010; Glenn et al., 1996; Hill et al., 2012; Shapiro et al., 1997). The other three studies found no difference (Chan & Chien 2017; Chan et al., 2005; Martin et al., 1998) in their ID participants. However, two studies finding a reduction in stereotyped behaviour did not control for the participant-staff ratio in the MSE (Cuvo et al. 2001; Fava et al. 2009). Another study only found positive effects when a family member was present compared to when the participant was alone (Glenn et al., 1996), which raises interesting questions about the mediating effect of social interaction. Compatible with this, two studies with null results both had low levels of staff engagement in the MSE (Martin et al. 1998; Chan et al. 2005). Although the other study with null results had a 1:1 participant-staff ratio (Chan & Chien, 2017).

Taken together, there is a tentative pattern for studies with one-to-one participant-staff ratios to find a reduction in stereotyped behaviour from MSE use and for studies with higher ratios to not establish such effects, although there is an exception to this. However, the low quality of many of these studies and the lack of direct manipulation of participant-staff ratio mean that conclusions are tentative.

Engagement and concentration

Engagement and concentration are terms used interchangeably within this literature to describe a participant's level of sustained involvement or compliance in an activity. Five out of the seven studies used measures specifically designed for their study but used the same measure for all participants (Ashby et al., 1995; Cuvo et al., 2001; Hill et al., 2012; Lindsay et al., 1997; Martin et al., 1998), whereas two studies defined specific outcomes for each participant (Kaplan et al., 2006; Mey et al., 2015). The measures varied in the behaviours that were coded but these included coding the frequency of looking behaviours or manipulating task related objects.

Six of the seven studies investigating engagement or concentration found an improvement from MSE use (Ashby et al., 1995; Cuvo et al., 2001; Hill et al., 2012; Kaplan et al., 2006; Lindsay et al., 1997; Mey et al., 2015) with the other study finding no improvement (Martin et al., 1998). However, some of these studies have found that engagement improved in other conditions as well as in the MSE (e.g. Cuvo et al., 2001; Lindsay et al., 1997). Additionally, Hill et al. (2012) found improved engagement in both the MSE and a living room condition, but this was only when caregiver attention to the participant was high. Therefore, this evidence suggests that the MSE is not unique in improving engagement, and that the level of carer attention needs to be considered.

In summary, an improvement in engagement from MSE use is one of the most robust findings across the measures, and the variety in measurement suggests that this finding is robust to different measurement techniques. However, this improvement may not be specific to the MSE, and the level of social interaction needs to be considered.

Adaptive and pro-social behaviour

Adaptive behaviour within the context of these studies describes positive social interaction and independence behaviours. Of the four studies that investigated adaptive behaviour, three used the BC (Chan & Chien, 2017; Chan et al., 2005; Shapiro et al., 1997), and one used a measure specific to their study (Lindsay et al. 2001). Only Lindsay et al. (2001) and Shapiro et al. (1997) found an improvement in adaptive behaviour from MSE use, but it is noteworthy, that both of the largest studies found no difference (Chan & Chien, 2017; Chan et al., 2005).

Adaptive behaviour includes pro-social behaviours, with four studies specifically investigating pro-social behaviours (i.e. not measuring the other behaviours associated with adaptive behaviours). All four studies assessing pro-social behaviour found benefits from MSE use (Fava & Strauss, 2010; Glenn et al., 1996; McKee et al., 2007; Mey et al., 2015), suggesting that the general measures of adaptive behaviour may be masking a specific effect of MSE use on pro-social behaviour. However, direct comparison is not possible as all of the studies on adaptive behaviour measured participants with ID, while three out of the four studies that investigated pro-social behaviour specifically measured autistic participants (Fava & Strauss, 2010; McKee et al., 2007; Mey et al., 2015). It is also notable that the improvement in pro-social behaviour was dependent on the way the MSE was used in two of the studies. Either depending on the participant having free choice of how to use the MSE (i.e. Snoezelen condition, Fava & Strauss, 2010), or having social interaction (Glenn et al., 1996). It is also notable that Mey et al.'s (2015) study contained no comparison group or condition, such that any improvement in pro-social behaviour may have been related to activities outside of the MSE or developmental maturation.

In summary, there is evidence that MSE use can improve pro-social behaviours specifically in autistic individuals, and there is less evidence that overall adaptive behaviours are affected by MSE use. However, the quality of studies finding an improvement in pro-social behaviours needs to be considered, along with the finding that the MSE may need to be used in specific ways for benefits to pro-social behaviour to occur.

Relaxation

Relaxation was measured differently by each of the four studies that included it, with Chan et al. (2005) using a published measure, Lindsay et al. (1997) and Mey et al. (2015) using different bespoke scales, and Martin et al. (1998) not providing any information. Of the four studies that measured relaxation, two found an improvement when post-MSE relaxation was compared to baseline relaxation (Chan et al., 2005; Mey et al., 2015). However, there was no change in relaxation between the MSE and control conditions, which were a standardised activity session (Chan et al. 2005) and a 'non-complex sensory environment' (Martin et al. 1998). There was also no difference in relaxation when comparing the MSE to other therapies measured by Lindsay et al. (1997) which included relaxation therapy, hand massage/aroma therapy, and active therapy. Mey et al. (2015) did not have a comparison group in their year-long study; therefore, the improvement in relaxation across conditions may relate to other generic factors. Indeed, during development children improve in self-regulation (Kochanska, Coy, & Murray, 2001), and emotion regulation (Denham et al., 2003), resulting in better controlled emotions and behaviour.

In summary, findings on relaxation are equivocal and similar improvements can be achieved in other environments.

Heart rate

Heart rate can be used as a measure of physiological state whereby a high heart rate indicates high arousal (i.e. anxiety or enjoyment), and low heart rate indicates low arousal (i.e. relaxation). Three studies measured heart rate, one using a 'physiologic monitor' (Chan & Chien 2017), another using a vest with integrated ECG monitors (Shapiro et al., 1997), and the other study only stating that pulse was measured (Chan et al. 2005). Both Chan et al. (2005) and Chan and Chien (2017) found no effect of MSE use on heart rate. However, both did not measure heart rate within MSE, only before and after each MSE session. The temporal sensitivity of heart rate (e.g. Berntson, Cacioppo, & Quigley, 1995) could mean that the effect of MSE on heart rate was not adequately captured. In contrast, Shapiro et al. (1997) found a significant change in heart rate within and after the MSE condition, compared to their control condition in which participants played in a 'regular' room. However, Shapiro et al. (1997) analysed the percentage heart rate change rather than the direction of change, and so whether the participant was experiencing higher arousal or lower arousal in the MSE condition is not known.

In summary, these findings are inconclusive as Chan et al. (2005) and Chan and Chien (2017) did not measure heart rate within the MSE, and Shapiro et al. (1997) reported findings without the direction of effect.

Alertness and responsiveness

Only two out of the 16 reviewed studies investigated alertness and responsiveness. Responsiveness/alertness was found to both increase (Ashby et al. 1995) and decrease (Chan & Chien 2017) from MSE use. However, Ashby et al. measured responsiveness during the MSE session and Chan and Chien (2017) measured alertness before and then ten weeks after MSE use. This highlights the important difference between measuring behaviours during MSE use or after but the differences between the two measurements does not afford a direct comparison of the findings. Notably, Chan and Chien had a relatively robust design and good sample size, whereas Ashby et al.'s study was descriptive.

In summary, given there have only been two studies and they have measured slightly different constructs, it would be premature to draw conclusions.

Emotional state

As with alertness and responsiveness, only two studies measured emotional state. Glenn et al. (1996) found that participants with ID showed more positive emotions (e.g. smiling) when they interacted in the MSE with a family member, compared to when they were alone. This suggests that sharing the experience with a family member may be important for improving positive emotions in the MSE, but it is not known if these findings extend to social interaction with a teacher or other non-family members. In addition, this finding was only descriptive and therefore provides limited evidence.

Better evidence comes from Chan et al. (2005) due to their large sample, robust design and statistical analysis. They found that, compared to baseline, MSE use improved emotions (i.e. reduced negative and neutral, and improved positive emotions). However, there was no significant difference in emotion between the MSE group and a control group who took part in a standardised activity. Additionally, the participant-staff ratio was not described for the control group so it is not possible to extrapolate the effect that staff attention may have had on these findings.

In summary, only two studies have investigated the effect of the MSE on emotion state, which limits the possibility of conclusions. The more robust study of Chan et al. (2005) suggests that the positive effects of the MSE on emotion can be achieved in other environments, similar to the findings for relaxation.

Learning

Two out of the 16 studies have investigated the effect of the MSE on learning. Both studies found that MSE use improved learning in their autistic (Mey et al. 2015) and severely disabled child participants (Houghton et al. 1998). Houghton et al. (1998) also found that the learnt skills could extend to other environments such as a farm. However, Mey et al. did not employ a comparison group or condition so it is possible the learning improved through other means over the 52 weeks of the study.

In conclusion, these findings indicate that the MSE may positively impact learning, but the evidence is limited.

Enjoyment

Enjoyment was only specifically measured in one study (Lindsay et al. 1997), even though some enjoyment behaviours were also coded within other studies under different coding categories (e.g. adaptive behaviour). Lindsay et al. (1997) report that the MSE and relaxation therapies were most enjoyed compared to other therapies, such as an active therapy and hand/massage therapy. As relaxation therapy, which only involved the participant laying down with music playing, was enjoyed as much as the MSE, the utility of an expensive MSE is drawn into question. However, even though Lindsay et al. report this effect, inspection of their results reveals that this effect was not statistically significant. This, added to the small sample size (n=8), indicates there is no substantive empirical evidence for MSEs improving enjoyment.

Relationship with the facilitator

Only Mey et al. (2015) investigated the effect of the MSE on relationship with the facilitator, with evidence triangulated from the individualised observations of the child by a facilitator, parent and teacher. In their sample of six autistic children they report that the MSE improved the relationship with the facilitator, but as discussed above, the lack of comparison condition or group limits these findings.

Autism severity

Only Novakovic et al. (2019) measured autism severity, and they found that it significantly decreased in the MSE group, compared to the group who had not used the MSE. However, there are methodological issues limiting this finding. Among other issues, participants continued to receive other therapy and interventions (e.g. occupational therapy) throughout the three-month study, suggesting that autistic severity could have decreased through other means.

Sensory functioning

Although some of the items included in the stereotyped behaviour coding were sensory in nature (e.g. sucks clothes; Shapiro et al. 1997), sensory functioning was also only specifically investigated by Mey et al. (2015). They reported an improvement in sensory functioning across the year that the participants used the MSE, but again the descriptive nature of this study, and lack of comparison group or condition limits this finding.

It is interesting that only one study has specifically measured sensory functioning when the MSE is purported to be a sensory intervention (e.g. Fava & Strauss, 2010; Hogg et al., 2001) working to improve outcomes through sensory stimulation. This could be because sensory impairments are not symptomatic of ID, even though they have been found in ID individuals (for review see, Carvill, 2001). Considering the nature of the MSE as a form of sensory intervention, and the increasing recognition of sensory issues associated with varying disorders, future studies should investigate the impact of the MSE on sensory functioning.

1.3.3 Summary of the effects of MSE use

Overall, there is limited or inconclusive evidence for the MSE affecting CB, adaptive behaviour, heart rate, alertness, emotional state, learning, enjoyment, relationship with the facilitator, autism severity, and sensory functioning. However, there is slightly more evidence for the MSE improving stereotyped behaviour, engagement, pro-social behaviours and relaxation. As discussed previously, methodological considerations demonstrate that the overall quality of the studies is poor which necessarily prevents definitive conclusions.

Only six studies have investigated the effects of MSE use specifically on children, and the two largest studies in the area, which arguably provide more convincing evidence of the effect of MSE use, included only adult participants (Chan & Chien, 2017), or adult and child participants in one sample (Chan et al. 2005). MSE use does not appear to be more beneficial for children or adults, but considering the widespread use of these rooms in special-needs schools in the UK and beyond (e.g. North America, Cuvo, May, & Post, 2001; China, Chan & Chien, 2017; Australia, Stephenson & Carter, 2011; and the UK, Bozic, 1997), more research on children is needed. It was also notable that only one study to date has specifically explored the effect of MSE use on autistic children. To inform the development of studies within this thesis, the next section will provide a specific overview of the MSE research on autistic individuals.

1.3.4 Findings on MSE use with autistic participants

Five studies tested the effects of the MSE on autistic participants, with four of these studies having small sample sizes (autistic *n*=3 in Kaplan et al. 2006, autistic *n*=3 in McKee et al., 2007; autistic *n*=9 in Fava & Strauss, 2010; autistic *n*=6 in Mey et al., 2015), who therefore presented largely descriptive findings, which limits their empirical value.

Fava and Strauss (2010) and Kaplan et al. (2006) both found a reduction in CBs from MSE use in their autistic adult participants compared to a control condition (i.e. living room, Fava & Struass 2010; 'non-MSE', Kaplan et al. 2006). However, Kaplan et al. (2006) only reports this finding for two out of their three participants. In contrast, McKee et al. (2007) reported an increase in CBs in one participant and no change in the other two adult participants both during and after MSE use. Therefore, there is inconsistent evidence that MSE use can improve CBs in autistic adults.

McKee et al. (2007) reported a tendency towards more pro-social behaviour in all their participants, yet they acknowledge that this tendency was inconsistent across participants and time. Kaplan et al. (2006) also reported disparate findings between their participants in relation to engagement, finding that only two out of the three participants showed improved engagement in the MSE. More broadly positive findings are reported by Mey et al. (2015) who investigated six intellectually low functioning autistic children (aged 5-8 years) across a school year, and found that MSE use improved sensory functioning, learning, concentration, relaxation, and adaptive behaviour, as well as the relationship with the teacher guiding the session. However, there was no comparison with another condition, limiting the utility of these findings.

The only study with an adequate sample size for analysis was conducted by Novakovic et al. (2019) who tested 40 adolescent and adult participants with autism and concurrent ID. In this study the participants were randomly divided into two groups, with one group (*n*=20) taking part in MSE sessions for 12 weeks, and the other group (*n*=20) not. They found that autism severity significantly decreased in the MSE group compared to the control group. However, as described previously, all participants continued to receive other therapies and interventions (e.g. speech therapy, occupational therapy) throughout the 12 weeks, limiting the conclusion that the MSE affected the change in autism severity. Indeed, as all participants had ID, the full range of the autistic spectrum was also not tested, and as participants were randomly assigned to the conditions (i.e. rather than using a matched-pairs design), heterogeneity between the groups remained somewhat uncontrolled. Overall, this study provides some evidence that a 12-week MSE intervention may improve core autistic symptomology in ID autistic adolescents and adults, but methodical issues limit this finding.

In summary, all studies with autistic participants reported some positive benefits suggesting that the MSE may promote beneficial outcomes, but some sample sizes are too small to generalise, and overall, methodological issues limit conclusions. Additionally, only one study specifically tested autistic *children* (Mey et al., 2015), even though they are widely used in special needs schools. It is clear that to adequately understand the effects of MSE use on autistic children further research is needed with larger samples and more rigorous methodologies.

1.4 Overview and aims of the thesis

Autism effects the daily life of autistic people and their families (e.g. Newschaffer et al., 2007), and therapies and interventions have been devised to improve sensory, cognitive and behavioural functioning. In particular, considering the sensory issues associated with autism, it is unsurprising that sensory therapies have increased in popularity for this sample. There is some evidence for the efficacy of SIT (for reviews see Baranek, 2002; Schoen et al., 2019) and music therapy (Geretsegger et al., 2014) but in both cases this evidence is limited by the lack of high-quality studies. MSEs, another form of sensory intervention, are widely used in special-needs schools. However, previous reviews have concluded that the significant methodological issues of existing studies mean that MSEs currently do not meet the required standards of evidence-based practice (Botts et al., 2008) and cannot be endorsed as a valid intervention (Lotan & Gold, 2009). The same conclusions are drawn from the present review as it has been demonstrated that findings on MSE use with varying participant groups (i.e. autism, ID and multiple severe disabilities) have been inconclusive, and that MSE use is not underpinned by validated theory. One previously discussed unvalidated theory (section 1.2.5) suggests that the MSE provides sensory stimulation that meets the needs of the user bringing about positive behavioural outcomes (e.g. Baillon et al., 2002). Indeed, this could predict benefit for some autistic individuals as those who are sensorially under-stimulated could gain the required stimulation within the MSE, which could remediate sensory seeking, and other sensory related behaviours (e.g. RMBs). Yet, this theory cannot explain the benefit to the autistic individual who is over-sensitive to sensory input, as increased stimulation would likely be unpleasant. However, another untested theory suggests that it is being able to control the stimulation received that enables benefits (e.g. Eijgendaal et al., 2010). This theory would predict benefit to a broader group of autistic individuals, as stimulation could be tailored to their differing sensory profiles. However, no theory has previously been applied to, or tested with, autistic individuals, and with the paucity of studies on autistic individuals, and differing behavioural (APA, 2013) and sensory profiles (e.g. Green et al., 2016), autism specific MSE investigations are needed. Finally, MSEs are widely used in special needs schools with autistic children but only one study to date has specifically investigated the effect of MSE use with this sample (Mey et al. 2015). Therefore, more MSE investigations with autistic children are needed.

This Chapter has highlighted another key priority for this field, namely, improved methodological rigour. However, the paucity of sound previous research means that new quantitative studies cannot be adequately empirically driven or underpinned by theory. Indeed, new qualitative studies would also not meet the key priority of the field because of their subjective and ungeneralizable nature. In the absence of an adequate literature on which to design a study, sequential mixed methods investigations (see Creswell, Plano Clark, Gutmann, & Hanson, 2003) allow for an empirically robust approach (Greene, Caracelli, & Graham, 1989), in which each methodology (i.e. quantitative and qualitative) serves to ameliorate the disadvantages associated with the other (Creswell et al., 2003; Ivankova, Creswell, & Stick, 2006). Within sequential mixed methods investigations, a qualitative study serves to provide in-depth insight and narrow the research focus (Creswell et al., 2003), enabling the formulation of relevant, and testable hypotheses. Subsequently, a quantitative study can be designed, based on the findings of the qualitative study, to objectively test the formulated hypotheses. Therefore, this thesis aims to adopt a sequential mixed methods approach to address the previous lack of methodological rigour in this field in order to provide valuable information about effects of MSEs on autistic children. Practically speaking, this will mean interviewing and subsequently, surveying experts (i.e. practitioners who regularly use MSEs with autistic children; Chapter 2), which will define theoretical questions, leading to testable hypotheses, that can be investigated through a quantitative study in an MSE (Chapter 4).

Finally, most studies in this field have compared MSE and ‘non-MSE’ conditions (e.g. MSE use vs. living room use, Cuvo et al. 2001) in an attempt to understand whether or not MSEs are effective. However, within the scientific method, the MSE and non-MSE conditions would need to be matched on all aspects apart from the manipulation (i.e. the MSE), and this is not possible as too many variables change between the conditions (e.g. type or level of sensory stimulation; equipment engaged with). For example, if a non-MSE condition is engagement with toys in a ‘regular’ room, one could argue that this too is a multi-sensory experience as all toys and objects have an inherent sensory quality. Indeed, even if the toys were somewhat matched to the MSE equipment in sensory quality, matching on other dimensions would be impossible (i.e. size, interest). As such non-MSE conditions are poor controls for the MSE, and poor control is consistently described as a core methodological issue of MSE research (Botts et al., 2008; Chan et al., 2010; Lai, 2003). Therefore, as improved methodological rigour is a key priority for this area, and comparison of an MSE with a non-MSE is affected by too many uncontrolled variables, different, equally important questions must be asked in the field. Indeed, theories of MSEs (section 1.2.5), although untested, suggest that different methods of MSE use can affect outcomes, and this has also been described in the literature (‘Uses of MSEs’, section 1.2.4). Further investigation into the effects of differing methods of use could provide insight into the mechanistic effects of the MSE and provide guidance to practitioners on how to use the MSE for maximal benefit. Therefore, investigating factors that affect outcomes has both theoretical and practical value, and as such, the final aim of this thesis is to investigate such factors, as defined by the practitioners in the qualitative study (Chapter 2).

As a final note, the need for improved methodological rigour dictates the use of sequential mixed methods. To maintain the integrity of this approach, a discussion of theoretical underpinnings of the main MSE study (Chapter 4) is only possible after the practitioners have defined the direction of the research (Chapter 2). As such, discussions of theoretical underpinnings can be found in the discussion section of Chapter 2 (section 2.4.2) and in Chapter 4 (section 4.1, 4.1.2, 4.4.1).

The aims of the thesis are as follows:

Aim 1: To investigate MSE use specifically for autistic children: The interviewed and surveyed practitioners in Chapter 2 are specifically asked about MSE use relating only to autistic individuals. Then, the coding scheme devised in Chapter 3 (based on autism relevant outcomes suggested by the practitioners in Chapter 2), is developed using previous observation and questionnaire measures specific to autistic individuals where possible. Finally, the studies presented in Chapter 4 and 5 are conducted with autistic participants.

Aim 2: To investigate MSEs in a methodologically rigorous way: A sequential mixed methods design is used, with the interviewed and surveyed practitioners' beliefs (Chapter 2) leading to the formulation of testable hypotheses to be investigated quantitatively (Chapter 4).

Aim 3: To investigate the effect of method of use on outcomes within an MSE: Based on previous MSE theory, qualitative and quantitative research, a practitioner-defined (Chapter 2) factor that affects MSE outcomes is investigated (Chapter 4).

Overall, the work presented in this thesis aimed to investigate the use and effect of MSEs with autistic children. Firstly, practitioners in the UK who regularly use MSEs with autistic children were interviewed and surveyed about their experiences and beliefs about the outcomes that are possible from MSE use, as well as the factors that affect these outcomes. Then, using these findings, an empirical study was designed to experimentally investigate the effect of the MSE on autistic children, for which a detailed observational coding scheme was developed. Finally, preferences of autistic children within an MSE were assessed. These in-depth mixed methods investigations provide valuable insight and can inform evidence-based practice with the hope of bringing maximum benefit to autistic children using MSEs.

1.5 Thesis outline

Chapter 2 presents a sequential mixed methods study into practitioner beliefs and experiences of MSE use with autistic children. These findings are then used to inform the design of a quantitative study within an MSE, described in Chapter 4 and 5.

Chapter 3 then outlines the process of designing an MSE at the Cardiff University Centre for Human Developmental Science (CUCHDS), and the designing of the observational behavioural coding schemes for the study described in Chapter 4 and 5. Also included in this Chapter are the interrater reliability analyses of these coding schemes.

Chapter 4 presents a study conducted within the CUCHDS MSE into the effect of having sensory control on the behaviour, mood and Heart Rate Variability (HRV) of autistic children.

Chapter 5 describes how the autistic sample from the study in Chapter 4 engaged within the MSE when they could play freely. This provides insight into autistic children's preferences within the MSE.

Finally, Chapter 6 highlights the key findings from the studies within this thesis and discusses strengths, limitations, implications and recommendations for future research.

Chapter 2: A Sequential Mixed-Methods Investigation into the Beliefs and Experiences of Practitioners Who Have Worked in Multi-Sensory Environments with Autistic Children

2.1 Introduction

Chapter 1 introduced the sensory issues associated with autism which can cause distress (Ben-Sasson et al., 2008) and negatively impact daily functioning (Schaaf, Toth-Cohen, Johnson, Outten, & Benevides, 2011). Therefore, it is not surprising that MSEs, which modify the sensory environment, are widely used for this population. Despite their wide use, there is a lack of research on MSE use with autistic children, and therefore there is limited understanding of the outcomes that are possible, and the most effective ways to use MSEs.

2.1.1 Findings of previous quantitative MSE studies

As outlined in Chapter 1, previous studies investigating the effect of MSE use have included participants with a range of conditions including ID, unspecified multiple disabilities, and autism, all with varied findings. A cluster of studies have found that MSE use has a beneficial effect on a range of outcomes (Cuvo et al., 2001; Glenn et al., 1996; Hill et al., 2012; Houghton et al., 1998; Lindsay et al., 2001, 1997; Mey et al., 2015; Novakovic et al., 2019; Shapiro et al., 1997; Singh et al., 2004). However, other studies have found that MSE use affects some outcomes but not others (Chan & Chien, 2017; Chan, Fung, Tong, & Thompson, 2005; Martin, Gaffan, & Williams, 1998). Whilst other studies still have found beneficial effects for some participants, but not for others (Fava & Strauss, 2010; Kaplan et al., 2006; McKee et al., 2007). The variation in findings has been partly attributed to a lack of methodological rigour, including small sample size, poorly measured outcomes, and confounds between experimental conditions (Botts, Hershfeldt, & Christensen-Sandfort, 2008; Chan et al., 2010; Hogg, Cavet, Lambe, & Smeddle, 2001; Lai, 2003; Lotan & Gold, 2009).

MSE studies with autistic individuals have measured the effect of the MSE on a wide-range of outcomes including challenging behaviour (Fava & Strauss, 2010; Kaplan et al., 2006; McKee et al., 2007), stereotypic behaviour (Fava & Strauss, 2010), pro-social behaviour (Fava & Strauss, 2010; McKee et al., 2007; Mey et al., 2015), autism severity (Novakovic et al., 2019), and relaxation, sensory functioning, learning, and the relationship with the facilitator (Mey et al., 2015). However, their findings also varied (see Chapter 1).

In previous MSE studies on varying populations, the reasoning for investigating specific outcomes is unclear. Indeed, considering that autistic individuals reportedly have distinct behavioural (APA, 2013) and sensory profiles (e.g. Green et al. 2015), it is possible that previously measured outcomes may not be relevant for an autistic sample. Previous MSE studies with autistic samples provide some insight into relevant outcomes, but they too do not report how these outcomes were selected. It remains that there could be other outcomes that *are* specifically relevant to this sample but have not yet been investigated. Practitioners who use MSEs with individuals with varying disabilities can provide further insight into possible outcomes from MSE use, including the factors that they believe affect these outcomes.

2.1.2 Findings of previous qualitative studies

By way of overview (for full review see Chapter 1), many interviewed practitioners stated that MSEs enabled relaxation (Ayre, 1998; Stephenson & Carter, 2011a, 2011b), enjoyment (Ayre, 1998; Bozic, 1997; Stephenson & Carter, 2011a, 2011b), learning (Ayre, 1998; Bozic, 1997; Stephenson & Carter, 2011a), reduced anxiety, improved attention, and facilitated relationship building (Stephenson & Carter, 2011a). Evidence from Carter and Stephenson's (2012) survey quantified what teachers in 19 schools believed about possible outcomes, with four of the most endorsed behavioural outcomes including relaxation, improved focus, gain in visual skills, and improvement in challenging behaviour. There was also considerable endorsement that building relationships, reduction in self-stimulatory behaviour and gaining cognitive skills were possible. These studies have provided additional validation for the use of relaxation, learning, attention, enjoyment and relationship building as outcome variables in quantitative studies, as well as providing insight into an additional positive outcome, that is, anxiety reduction.

Qualitative studies also provide insight into factors that affect outcomes from MSE use. The Snoezelen® approach dictated that the child must have free-choice of how to use the MSE with no adult intervention (Hulsegge & Verheul, 1986). Some interviewed practitioners have endorsed this approach as enabling benefits (Ayre, 1998; Bozic, 1997; Stephenson & Carter, 2011a). Specifically, some of the teachers interviewed by Bozic (1997) stated that this approach enhanced relaxation, enjoyment and communication in their pupils. In addition, both Stephenson and Carter (2011a) and Ayre's (1998) participants identified that using the MSE with the child in control brought benefits. However, other practitioners endorsed a more flexible approach to MSE use, where the child can make choices but they are guided by the teacher to enable development and positive outcomes (Bozic, 1997; Stephenson & Carter, 2011a). However, as these studies referred to MSE users with varying disabilities, it remains unclear how either of these methods would affect autistic individuals. On one hand, the autistic child may benefit from the freedom to choose how they engage and from being able to tailor the MSE session to their needs. On the other hand, autistic individuals have been found to benefit from structured intervention sessions (e.g. Schopler, Brehm, Kinsbourne, & Reichler, 1971), and, therefore, the practitioner leading the session could be more beneficial.

The limited exploration of the specific experiences of autistic people in MSEs make clear that further research is needed. The ways MSEs are used for maximal benefit and the experimental design of future studies, particularly the outcome measures, should be informed by user profile and experience. Previous research interviewing practitioners (Ayre, 1998; Bozic, 1997; Pagliano, 1998; Stephenson & Carter, 2011a) has been fruitful in establishing possible benefits and some methods of MSE use. However, the best methods of use and outcomes specifically for autistic children have not been investigated. To date there have been no previous attempts to systematically investigate the beliefs and experiences of practitioners about MSE use for autistic children. Such insight is critical to inform understanding of the current use and perceived utility of MSEs with autistic children and will inform future studies that aim to systematically measure the potential benefits of MSE use.

In the UK, schools are the most common place where autistic children access MSEs. Therefore, in the present study educational practitioners from schools were recruited, and a sequential mixed-methods design was employed to investigate their beliefs and experiences. First, in Study 1, semi-structured interviews were used to gain in-depth insight into the beliefs and experiences of educational practitioners about MSE use with autistic children. Second, in Study 2, a follow-up survey was designed based on the findings of Study 1 and was be distributed to a larger group of practitioners. This enabled quantitative measurement of the endorsement of different key beliefs about MSE use and outcomes, as well as exploration of possible factors that may influence beliefs. The primary research questions are:

1. What are the beliefs and experiences of educational practitioners about the possible outcomes and overall efficacy of using MSEs with autistic children?
2. What factors do practitioners believe may affect possible outcomes in the MSE for autistic children?

2.2 Study 1: Practitioner beliefs and experiences of using an MSE with autistic children: insight from interviews

2.2.1 Method

2.2.1.1 Participants

To recruit participants for this study, head teachers of seven special-needs schools known to the research group (six in Wales and one in Suffolk, England) were contacted. One school did not respond, but head teachers from the other six schools volunteered staff members who met the inclusion criteria of having experience working in an MSE with autistic children.

The ten interviewed practitioners (nine female) from six special-needs schools were aged 24-62 years (M=44.3, SD=14.0), and had been working with autistic children in MSEs for 3-25 years

(*M*=13.3, *SD*=8.61). Eight were teachers and two were teaching assistants. Two other practitioners were interviewed but it emerged that they did not meet the inclusion criteria of having worked in an MSE with autistic pupils, and therefore, their data were not included in the analysis. Each school had an MSE that was typical (i.e. in-line with the definition provided in Chapter 1), and the equipment included in each MSE can be found in Table 2.1 (discussed further in Chapter 3). Ethical approval for this study was granted by the School of Psychology Ethics Committee, Cardiff University.

Table 2.1. Equipment in the Multi-Sensory Environments (MSEs) of the educational practitioners who were interviewed

School	**Bubble tube**	**Coloured room lighting**	**Projector**	**CD player**	**Mirror ball**	**Tactile wall/floor items**	**Fibre optics**	**Interactive light & sound ladder**	**Infinity tunnel**	**UV light**	**Other**
Percentage of MSEs with item	100	83	67	67	67	67	50	50	33	33	
1	√	√		√	√	√	√			√	
2	√	√	√	√	√	√	√	√	√		Sound board
3	√	√	√		√	√	√	√			Apple TV
4	√	√				√					
5	√	√	√	√	√			√	√	√	
6	√		√	√							Eye tracker

2.2.1.2 Materials

The creation of the interview schedule was guided by the research questions and refined using a framework outlined in Braun and Clarke (2013, page 85). The interview began with demographic questions, followed by questions about the use of the MSE and whether MSE use was associated with behaviour change in autistic children. The interview then explored the effects of the equipment in the MSE that engaged specific senses, which was followed by broader questions regarding the perceived outcomes of the MSE, both benefits and drawbacks. Finally, practitioners were asked if there was anything they would like to add. The interviews were semi-structured, so some answers were followed-up with questions not outlined on the interview schedule if clarity was needed. The interview schedule can be found in Appendix A.

2.2.1.3 Procedure

Six of the interviews were conducted within the MSE at each school to support the practitioners in recalling their experiences. However, timetabling conflicts meant that the other four interviews had to take place in meeting rooms. The interviews lasted 30-83 minutes (*M*=49.86, *SD*=15.67), and were all audio recorded for later transcription.

2.2.1.4 Analysis

The interviews were conducted by KU, transcribed verbatim into Microsoft Word, and then were uploaded into NVivo software (NVivo, 2012). Inductive thematic analysis (TA; Braun & Clarke, 2006, 2013) within an essentialist framework was used to analyse the data. TA is a method of analysis centred on the identification of codes, which are identifiable statements on the same topic that are endorsed by multiple participants. These highly used codes then form themes which reflect the commonality between a particular cluster of codes. The same 20% of the data was coded independently by the primary coder (KU) and a secondary coder (LH) to devise a coding scheme that captured the different types of response. A process of negotiated agreement (as described in Campbell, Quincy, Osserman, & Pedersen, 2013) was then used to agree a final coding scheme that best reflected the data. Both coders then coded another 10% of the data to validate the final coding scheme and to highlight any coding biases. All interviews were then coded by the primary coder (KU) using the final coding scheme, adding in emergent codes where necessary. The codes were then assessed for similarity in topic and subsequently themes and sub-themes were identified. After completion of the original analyses, the themes and sub-themes were further refined by the rest of the core research team (CJ and GP, in addition to KU).

Although an inductive approach to data analysis was taken, it is acknowledged that KU’s views, experiences and biases may have impacted the analysis (Berger, 2015; Braun & Clarke, 2006; Sword, 1999). Therefore, through a process of active acknowledgement (Horsburgh, 2003), it is hoped that the reader can assess the validity of this research for themselves. KU was new to the area of MSE research and had not worked in, or observed, an MSE session before. The MSE literature provided some background but the methodological issues associated with this research led KU to be uncertain about the effect of MSEs. As such, KU approached the interviewed practitioners as experts who could provide in-depth information about MSEs. For this reason, and to readdress the typical power imbalance of the researcher being the expert studying naïve subjects (Horsburgh, 2003), KU purposefully described herself to the practitioners as a student needing to learn from experts (Berger, 2015; Sword, 1999). It is hoped that this approach would have empowered the practitioners (Berger & Malkinson, 2000) and encouraged them to share freely, providing a more accurate representation of their beliefs. Finally, to mitigate the effect of KU’s unconscious biases, there was constant engagement with the wider research team, comprised of scientists also new to MSE research.

2.2.2 Results

Six themes emerged: (1) MSEs benefit cognition, behaviour and mood, (2) MSEs have distinct properties that facilitate benefits, (3) MSE use should be centred on the child’s needs, (4) MSEs are most effective when the practitioner plays an active role, (5) MSEs can be used for teaching and learning, and (6) MSE use can present challenges. Relationships between the themes also emerged, and these are discussed below and are visually conceptualised in Figure 2.1. The codes within each theme are highlighted in bold text.

2.2.2.1 Theme 1: MSEs benefit cognition, behaviour and mood

The practitioners believed that MSEs brought numerous benefits for autistic children. These included benefits to cognition (focus and attention) and behaviour (increase in social interaction and communication), and reduction in repetitive motor behaviours (RMBs), improvement in mood, and reduction in anxiety.

The practitioners believed that the MSE could improve **focus and attention** in their autistic pupils, "[I've] seen them show better concentration and focus [within the MSE]", and "It gains their attention a bit better and they focus like a lot more on those sorts of activities [within the MSE]". It was suggested that being in the MSE removed sensory distractions and therefore, enabled focus. This sub-theme links heavily with the 'MSEs can be used for teaching and learning' theme. Specifically, the MSE works to focus the children for learning both inside and outside the MSE, "From the sensory room they [the pupils] are starting to be engaged with the different lighting effects that are changing colours and actually focussing on that, then seeing that calmness and the focus is then sort of starting to seep then into the lesson engagement".

According to all the practitioners, the MSE led to improvements in **social interaction and communication**. The autistic children were repeatedly described as, "…more interactive", and "Speaking more you know… people [that] are not necessarily that vocal elsewhere". Not only was it described that the children using the MSE *engaged* in more interactions, but that "…they are much more likely to initiate interaction in this room [the MSE]". This sub-theme was linked to the 'MSE as motivational' sub-theme from the 'MSEs have distinct properties that facilitate benefit' theme. The practitioners suggested that because the MSE was motivational for the child, increases in social interaction and communication followed, "You would switch it off and they would reach for the switch ...they might sign 'Please', so you've got some communication." Another practitioner said that within the MSE the children, "…communicate a little bit more because they really love [the MSE]".

Almost all the practitioners stated that the MSE can lead to a reduction in **RMBs**. Many of the references within this sub-theme suggested that because sensory needs were met, RMBs were reduced, "For one little boy you get less of the flapping because he's getting stimulation". It was also suggested that RMBs could be reduced because the MSE provides more enjoyable activities, "You reduce the rocking time because the enjoyable stuff has taken over". However, it was accepted that these changes would not be instantaneous, "I have seen changes [in RMBs] but they're not going to be immediate because their behaviours are something that they have done for years".

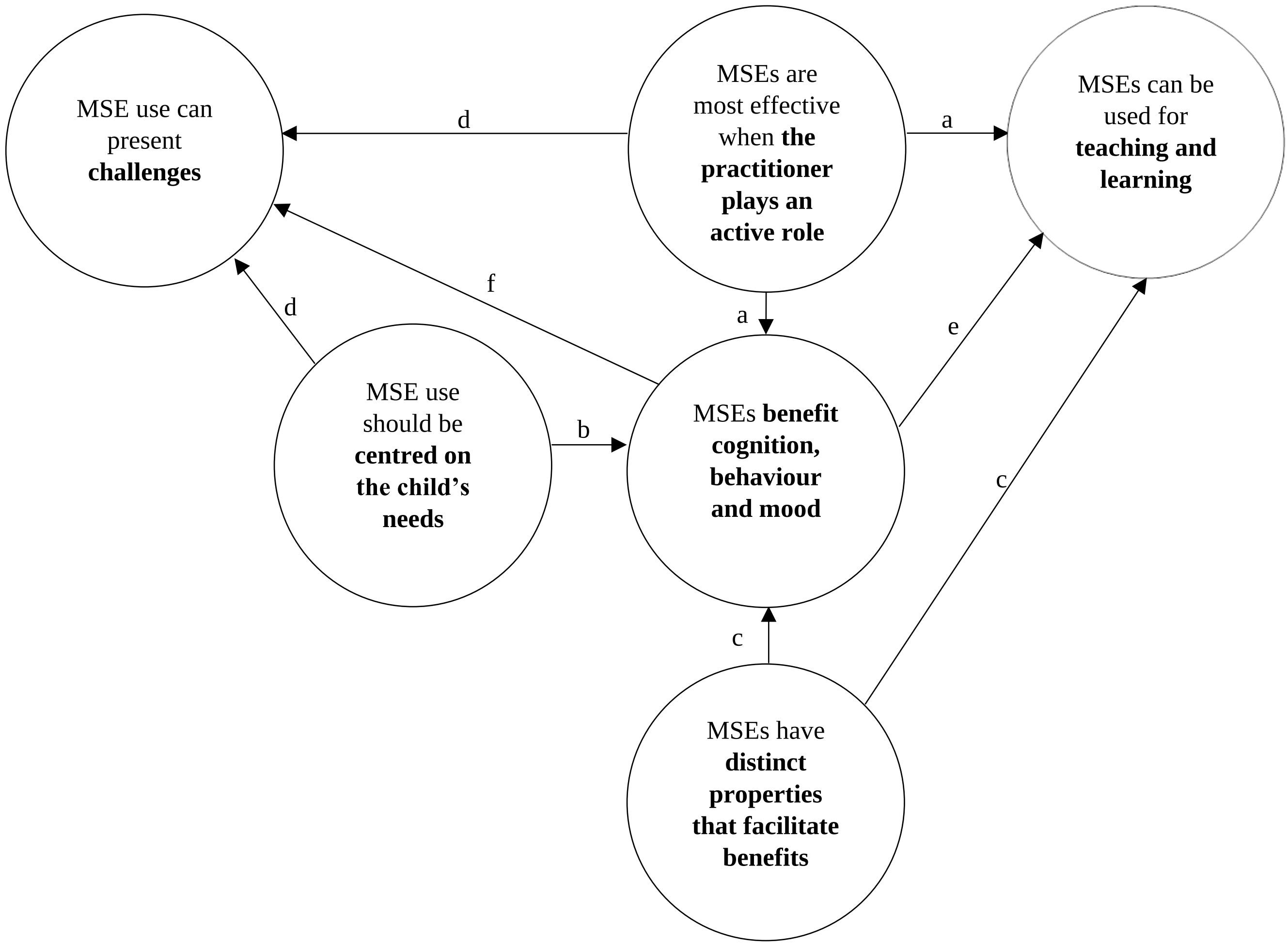


Figure 2.1. Graphical representation of the themes and their relationships with each other, as described by the practitioners. Paths a-f represent links between themes that were described by practitioners: a) The active practitioner can bring about benefits, as well as enabling teaching and learning; some suggested that these outcomes would not be possible without an active practitioner, b) MSE use should be centred on the child's needs for benefits to occur, c) The distinct properties of the MSE (e.g. it being motivational) not only facilitate benefits to cognition, behaviour and mood but also, teaching and learning, d) MSE use can present challenges and these typically occur when the MSE is not being used in accordance with the child's needs and when the practitioner is not actively playing their role, e) The MSE works to focus the children for learning both inside and outside the MSE, f) Some outcomes (e.g. reduction in RMBs) can take time to emerge.

Mood and anxiety were described as positively affected in the MSE. One practitioner suggested that the relationship between MSE use and mood was straightforward, "I just think some learners are a bit sad and this makes them happy, it's as simple as it gets". However, other practitioners described positive changes in mood as an indirect benefit which was brought about by a reduction in anxiety, "If they are very anxious it can help them calm and that will have a big effect on their emotional state, sometimes it makes them really happy". Reduction in anxiety was also described as facilitating other benefits including the reduction in RMBs, "You can see it in their body, they just relax and some of their stereotypical behaviours diminish". Therefore, one of the main benefits of MSE use for the child was a reduction in anxiety, which then allowed for a range of other benefits to occur.

Benefits from using the room were also described by some practitioners as continuing or being **carried over** beyond the MSE session. One practitioner noted that a student, "Stopped harming himself outside as well as in the sensory [room]". Calmness was also suggested to continue beyond the session, "They would sort of have that calmness then and transfer into the class". However, not all the practitioners fully agreed, "as soon as you leave the room [the MSE], you then haven't got calm and quiet environment because you are back into a busy class and you're less likely to get such good concentration from them". Some suggested that the environment that the child enters after the MSE determines whether carry-over effects are possible.

2.2.2.2 Theme 2: MSEs have distinct properties that facilitate benefits

The practitioners believed that MSEs had distinct properties that facilitated benefits such as **the child being able to be in control of their environment**. The practitioners stated that the MSE was a unique space where the child could control their immediate sensory environment, and this facilitated benefits such as reducing challenging behaviours, "It's always much better if you push a button or you turn something rather than scream, shout, kick, punch. So what you're doing is you're trying to say, you can control your environment but this is the way we would like you to control the environment or this is how we would like you to calm down." Another practitioner suggested that control over the MSE enabled environment modulation and therefore, coping, "getting them to control it [the MSE] so if it's too loud or its too quiet they can cope with it".

As previously discussed in reference to the 'Social interaction and communication' outcome, the MSE was described as **motivational**, "It's motivating, and when you have ASD motivation is much more difficult to find". It was repeatedly stated that the motivational nature of the MSE led to multiple beneficial outcomes including communication, "It's a motivating session for them so you tend to get better communication." It was also suggested that preferred objects needed to be identified within the MSE to enable motivation and subsequently, communication, "I think one of the primary ways that I use it [the MSE] with ASD learners… [is] finding preferred and non-preferred objects, so it's just getting them motived and going right, they love that, let's get asking for that and you know using it as a form of communication".

Practitioners described how being in the MSE facilitated **relationship building**. They suggested that within the MSE, the amount of interaction between the child, the practitioner and the child's peers increased. This increase in interaction subsequently enabled stronger relationships to be built, "It's just enjoying something with another adult and developing that bond that you could potentially take back [to the classroom]". Many practitioners stated that relationships could be built more quickly within the MSE, and generally were better in quality to those relationships built within the classroom. However, it was also reported that the relationships built in the MSE could be transferred to the classroom, thereby continuing to bring about benefits, beyond the MSE session. Therefore, this relationship building sub-theme links to the benefits being carried-over sub-theme. The MSE was also described numerous times as enabling better relationships between the child and their peers, "When we started here, none of the pupils knew each other, and when you bring them into a sensory environment [the MSE] you get that group feeling". It was also suggested that the MSE leads to children being more accepting of their peers, "They are sort of accepting other people socially". Some suggested that this occurred because the children were enjoying themselves and thus were willing to accept other people being in their space.

Finally, some practitioners highlighted that the MSE provided **sensory stimulation** and therefore, benefits were possible, "For one little boy you get less of the flapping because he's getting stimulation". However, as described in the 'MSE use can present challenges' theme, practitioners suggested that the MSE can be over-stimulating for some individuals.

2.2.2.3 Theme 3: MSE use should be centred on the child's needs

The centrality of the child theme, i.e. recognising each child as an individual, emerged across all the interviews, emphasising its importance, "[We are] focussing on what that person needs and tailoring how you use that room to those individual needs." This centrality of the child was key to avoiding negative outcomes and enabling positive ones. It was stated that the **child's needs, capabilities and preferences determined *whether or not* the MSE should be used**, "The class I had last year was a class of more able children... we didn't come here [to the MSE]. They... were all diagnosed with autism but they didn't necessarily have sensory needs enough to need, appreciate or want this." However, the child's ability does not necessarily indicate that the MSE should not be used as one practitioner states, "Our most able children… are still really sensory. We've got a lad in class this year who has come to us from a mainstream school… but his sensory needs are huge and he needs time like this [referring to MSE] where he can have just down time, he can just have that quiet, sort of calm, time with an adult as well." Therefore, the MSE can be beneficial for some but, "[For] some children it is too much and you can distress and aggravate them", and as such, the practitioners advocate that the child's needs, capabilities and preferences determined *whether or not* the MSE should be used.

Further to this, it was suggested that a **child's needs, capabilities and preferences determined *how* the MSE should be used**, "We tend to be more child led, so we go with what we feel the child is looking for or depending on what sort of session and the ability of the children, it can be structured or unstructured." One clear motivation for adjusting activities was the perceived ability of the pupils, "We do bring the... much more able pupils [to the MSE] but we would then change the activity for them." It was clear that the MSE should always be tailored to the individual, "They are all different so, it's not a one size fits all, that's the thing. Different things do different things for different children".

It was also stated that a **child's needs, capabilities and preferences determined *what* the benefits of the MSE could be,** "You'd have to know them really well to know what you wanted to get out of the session." This analysis of the child and tailoring of activities ensures that the sessions are useful, "You don't bring people in who are really, really tired and do lovely relaxing cloths and smells and then they leave sleeping, because there's no point".

2.2.2.4 Theme 4: MSEs are most effective when the practitioner plays an active role

An **active practitioner** was suggested as key for positive outcomes for children, "The most important piece of equipment is the adult who is working with the child" and, "Their [the practitioner's] knowledge of the room, the equipment and the child is really, really key". This was described as particularly relevant to enabling carry-over effects from the MSE to other environments, "The adults have got to be very knowledgeable about what they're doing and then help that young person [and] give them the strategies so that they can then transfer that into other environments". This theme linked heavily with the, "MSE use should be centred on the child's needs" theme as it was repeatedly stated that an active practitioner was necessary to understand the child's needs and then use the MSE accordingly.

Practitioners also stated that **more training and research** was needed, "I don't think there is really enough training and research-based training for staff". One practitioner summed up the sentiments of many when they said, "I think people's knowledge of children and equipment and what they can do in the room is really important and training, I think that's really quite key."

The interviewed practitioners stated that they used the MSE both one-to-one and with groups of students. Some practitioners stated that one-to-one interactions within the MSE were qualitatively better than those in other settings because the child's sensory needs are met. However, others instead highlighted the importance of the practitioner over the MSE, "It might not necessarily be the room, it's the close relationship and working one-to-one".

2.2.2.5 Theme 5: MSEs can be used for teaching and learning

Many of the practitioners described the MSE as an effective **teaching and learning** environment and some considered this the main purpose of the MSE. When asked why they believed the MSE was a good teaching and learning environment, a practitioner responded, "It's fun, you know, and they don't realise that they're learning when they're having fun". This response reflected the opinions of many other practitioners. Alongside MSEs facilitating learning within the room practitioners also reported that they prepare the child for learning back in the classroom, "A really big area is readiness for learning. So stimulating them to bring them up, ready to learn, to go back to class or bringing them down so that they are ready to learn when they go back to class." Practitioners believed that a barrier to learning for autistic pupils was their sensory needs but that "[The MSE] helps to eliminate some of those things [sensory needs] so that they can start to learn". As such, "the environment in the sensory room can offer what you wouldn't necessarily get in the classroom." This concept of **the MSE being a unique space that offers more possibilities than a typical classroom** arose many times throughout the interviews. As this was the case, some practitioners expressed frustration at how the MSE was often used as a, "cop-out" or for, "chill-out time" by other practitioners, "they [MSEs] are not a chill-out space, this is a learning environment". They highlighted that the MSE was a resource that must be actively engaged with to bring about positive outcomes, linking to the previous theme of the active practitioner.

2.2.2.6 Theme 6: MSE use can present challenges

Although the MSE has many benefits, some practitioners stated that MSE use can lead to **negative behavioural outcomes**, "He showed signs of distress each time so… he had to be taken from there [the MSE]." Another practitioner described challenging behaviours in the MSE as, "…screaming, high pitched, some slapping behaviour and maybe self-harm and hair pulling and potentially could reach out to bite things." One practitioner noted a possible reason behind the behaviours, "They become over obsessive with it [the MSE], that can cause behaviours in itself." These codes linked heavily with the codes under the 'MSEs are most effective when the practitioner plays an active role' theme and the 'MSE use should be centred on the child's needs' theme. The practitioners described that it was up to them to actively assess whether the room would be suitable for a child. This was done on the basis of the child's needs, preferences and capabilities.

Another challenge for MSE use was that the **benefits require time to emerge,** "I have seen changes but they're not going to be immediate", and "[It's] just the case of being patient and waiting, playing the waiting game then and seeing how they draw out eventually". It emerged that for some children however, the effects of the MSE can be instantaneous, especially when it is used to calm a child after they have become agitated. This theme links back to the 'MSE use should be centred on the child's needs' theme as each individual's needs, capabilities and preferences affect their response to the MSE.

Although MSEs were described has having many properties that led to multiple benefits, it was recognised that **some of these benefits were not necessarily unique to the MSE**, "I guess when you're sort of so focussed on this environment [the MSE] it makes it seem like this is the only thing that works for them and it's not you know." Another practitioner furthers this by saying, "I wouldn't say it's purely just from being down in this room you know [that benefits emerge], we do get other, you know, equally as good responses in other settings". Even though practitioners believed that benefits could be gained in other places, the MSE was still described as being an important tool, "Obviously, this [the MSE] is just one piece of a very large puzzle to meet their needs, even though it's really, really… important piece and a very effective piece."

2.2.3 Summary of Study 1

In Study 1, 10 practitioners working in special-needs schools with autistic children were interviewed and these practitioners believed that MSEs have multiple benefits and distinct properties that facilitate these benefits. The practitioners also suggested that MSE use should be tailored to the child, and that an active practitioner was necessary to elicit benefits. Yet, they also believed that there were challenges to MSE use. As there has been limited investigation of the effect of MSE use on autistic children, these in-depth insights are integral for the field. However, it is unknown how widely endorsed these beliefs are beyond the 10 practitioners interviewed in the study. Further, no study to date has reflected on factors that may influence practitioner's beliefs and educational approaches, such as the amount of training or years of experience of working in an MSE. Therefore, to quantitively measure the relative endorsement of key beliefs described in this study, and to explore factors which affect these beliefs, a survey was designed from these interview findings and distributed to a larger sample of practitioners.

2.3 Study 2: Practitioner beliefs and experiences of using an MSE with autistic children: insight from a survey

2.3.1 Methods

2.3.1.1 Participants

Multiple recruitment strategies were employed to recruit practitioners to take part in this study. Head teachers from 726 special-needs schools across the UK were contacted and asked to distribute the online survey link to any of their staff who used an MSE with autistic children. These head teachers were either known to the research group or their email addresses were included in online databases for special-needs schools who cater to autistic pupils. Invitations to participate were also included on the National Autistic Society website, Facebook and Twitter page, and the Wales Autism Research Centre Facebook and Twitter page. Finally, an advert was included in a local SEN magazine. Although recruitment focussed on school teachers, the inclusion criteria allowed for different professionals to take part providing that they had worked in an MSE with school-aged autistic children.

Responses were received from 105 practitioners. However, three respondents were excluded as they did not meet the inclusion criteria for the study; two respondents had not worked with school-age children in an MSE, and one respondent did not provide enough information to confirm that they had worked with autistic children. The final sample included 102 practitioners (93 female) from 56 different organisations (Table 2.2) who were aged 21-68 years (M=40.4, SD=10.7) and had 2-35 years

(*M*=11.1, *SD*=7.7) experience working in MSEs with autistic children. Out of the respondents, 68% had received training on the use of MSEs.

Table 2.2. Organisations employing survey respondents

Organisation type	*N* (%)
Special-needs school	92 (90)
Mainstream school	3 (3)
NHS*	5 (5)
Charity	1 (1)
Autism resource base	1 (1)
Total	**102 (100)**

*NHS: National Health Service

The majority of respondents were teachers or teaching assistants (Table 2.3) with 93% of respondents working in schools. The pattern of survey data for the teachers and teaching assistants' group did not differ from the group containing other non-school based practitioners, nor did it differ from those who were based in schools but were not teachers or teaching assistants. Therefore, the full sample were analysed together.

Table 2.3. Occupations of survey respondents

Occupation	*N* (%)
Teacher	44 (43)
Teaching assistant	22 (22)
Head/Assistant head teacher	14 (14)
Occupational therapist	10 (10)
Speech and language therapist	4 (4)
Behaviour specialists	4 (4)
Care manager	1 (1)
Assistant psychologist	1 (1)
Music therapist	1 (1)
Physiotherapist	1 (1)
Total	**102 (100)**

The equipment included in the MSEs used by the surveyed practitioners are included in Table 2.4 (discussed further in Chapter 3).

Table 2.4. Equipment in the Multi-Sensory Environments (MSEs) of the organisations who participated in the survey study

Equipment	Percentage of MSEs with item
Projector	90
Bubble tube	89
CD player	87
Coloured room lights	84
Mirrors	81

Fibre optics	79
Sensory toys	79
UV lights	71
Mirror ball	62
Tactile wall	57
Colour wheel	51
iPad	46
Sound and light panel	44
Infinity panel	35
Sound wall	30
Aroma diffuser	25
Voice changer	11

Ethical approval for this study was granted by the School of Psychology Ethics Committee, Cardiff University.

2.3.1.2 Materials

The survey was devised using codes from Study 1. For a code to be included as a survey item it needed to be highly endorsed within its respective theme. The level of endorsement of the code was assessed by the number of practitioners who used it, and how much the code was repeated across the interviews. An attempt was made to ensure that the codes selected for inclusion were representative of the interviews (Study 1). The wording of some codes was changed for clarity, for example 'Benefit for focus and attention' was amended to 'Helps them to focus and pay attention'. The survey needed to be short enough to encourage practitioner engagment. Therefore, 28 items were chosen, in addition to 10 demographic questions. Five codes were reverse worded to ensure the survey contained equal numbers of statements that were positive, and negative about MSEs (e.g. the code 'decreases challenging behaviours' was reverse worded to be ' increases challenging behaviours') to limit acquiescence bias (e.g. Holbrook, 2008). Responses to each statement were on a five-point Likert scale from 'strongly agree' to 'strongly disagree'. The items were pseudorandomised and inputted into a survey format on Qualtrics software (Qualtrics, 2005).

To pilot the survey, it was sent to 14 practitioners known to the research group, and feedback was obtained from three practitioners (M=41.67 years, SD=16.26), all of whom were female. Overall, they reported that the survey was easy to follow but they suggested some small changes to wording for clarity, and all changes were incorporated. The final survey can be found in Appendix B.

2.3.1.3 Analysis plan

Percentage endorsement of individual codes and whole themes were analysed. Ordinal logistic regressions (OLR) investigated whether training or number of years of experience affected endorsement of items.

2.3.2 Results

2.3.2.1 Survey item endorsement

Whole sample percentage agreement with each statement are presented in Table 2.5. One item within the survey, “The MSE is more beneficial for pupils with ASD than pupils with other special needs”, appeared equivocal as more than a third of the sample neither agreed nor disagreed with it. The research team were concerned that not all practitioners had experience using the MSE with non-autistic pupils, and therefore, this item was excluded from overall theme percentage agreement. Overall theme percentage agreement can be found in Table 2.6. Items that were reverse worded according to the theme title were reverse scored, for example ‘strongly disagree’ responses were converted to ‘strongly agree’. Unless otherwise stated, in discussing the results the responses ‘strongly agreed’ and ‘somewhat agree’ have been summed to create a general agreement score, giving a broad indicator of participant endorsement of items. The responses ‘somewhat disagree’ and ‘strongly disagree’ have been treated similarly.

Overall, there was highest agreement with theme 3, ‘MSE use should be centred on the child’s needs’ (89%), yet three other themes were also highly endorsed (theme 2, ‘MSEs have distinct properties that facilitate benefits’, 87%; theme 1, ‘MSEs benefit cognition, behaviour and mood’, 85%; theme 4, ‘MSEs are most effective when the practitioner plays an active role’, 80%). However, there was less agreement with theme 5, ‘MSEs can be used for teaching and learning’ (58%) and theme 6, ‘MSE use can present challenges’ (33%) themes.

As would be expected based on the overall percentage data, the majority of *individual* items in themes 1-4 were highly endorsed. At an individual item level, within theme 1, ‘MSEs benefit cognition, behaviour and mood’, practitioners most highly agreed that the MSE could give enjoyment (98%), reduce anxiety (92%) and create or increase a positive mood (92%). There was also high endorsement for some negatively worded items, for example, 84% of practitioners *disagreed* that MSE use increases challenging behaviours. Overall, the practitioners were highly positive about the beneficial outcomes from MSE use.

Considering individual items in themes 2, 3 and 4, all these items were endorsed by at least 73% of the respondents, with the most highly endorsed item in each themes being, ‘Using the MSE with a pupil helps to build your relationship with them’ (93%, theme 2), ‘How the MSE should be used is determined by the pupil's needs (e.g. sensory needs, learning needs)’ (100%, theme 3), and ‘Training would benefit the way I use the MSE’ (85%, theme 4). The least well endorsed item of all three themes was ‘The most important factor in a successful MSE session is an active practitioner working with the pupil’ (73%, theme 4).

In contrast, there was more disparity in responses to items in themes 5 and 6. Within theme 5, 'MSEs can be used for teaching and learning', the item 'There are teaching possibilities in the MSE not available in the classroom' (94%) was very highly endorsed, whilst 'The most important outcome from the MSE is that the pupil learns' (23%) was the least well endorsed. The 'most important outcome from the MSE is that the pupil had fun' also received more modest endorsement, with only 56% agreement.

For theme 6, 'MSE use can present challenges', there was generally low agreement for these items. In particular, MSE use 'Leads to them becoming over-stimulated' (19%) was poorly endorsed, but it is still noteworthy that almost a fifth of the sample believed that the MSE could be overstimulating. However, there was slightly higher agreement that 'The MSE does not always bring benefits' (52%), and 'The benefits from using the MSE could be achieved using other school activities (e.g. craft time, storytelling)' (30%).

2.3.2.2 Impact of training and years of experience on participant response

Cumulative odds OLR with proportional odds were conducted to see whether practitioner training or years of experience of working in an MSE with autistic children predicted the likelihood of endorsing the 10 possible outcomes included in the survey (labelled with † in Table 2.5). No multicollinearity was present. However, two analyses violated the proportional odds assumption and were therefore not included in the final analyses. No OLRs were significant with years of experience as the predictor. For analyses with training as the predictor, years of experience were controlled for. It was found that the odds of practitioners with *no* training *agreeing* that the MSE would make autistic children less likely to initiate communication was .43 times that of practitioners who had received training, ($\chi^2(1)=4.03$, $p<.045$). Also, the odds of practitioners with *no* training *disagreeing* that the MSE would lead to increases the quality of communication (e.g. eye contact, gesturing, conversation) for autistic children was 2.69 times that of practitioners who had received training ($\chi^2(1)=5.22$, $p<.02$). Finally, the odds of practitioners with *no* training *disagreeing* that MSEs help those with autism to focus and pay attention being 3.73 times that of practitioners who had received training ($\chi^2(1)=9.01$, $p=.003$). That is, practitioners who had received training were almost four times more likely to agree that the MSE would improve focus and attention. However, after Bonferroni correction ($p<.006$) only the effect of training on beliefs about focus and attention was significant.

Table 2.5. Percentage agreement for each survey item, organised by theme

	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Strongly Disagree
Theme 1: MSEs benefit cognition, behaviour and mood					
Gives them enjoyment†	69	29	2	0	0
Reduces their anxiety†	57	35	5	2	1
Increases challenging behaviours (e.g. hitting, biting, self-harming) †*	0	7	9	29	55
Makes them less likely to initiate communication†*	1	3	13	39	44
Increases repetitive behaviours (e.g. repetitively fiddling with equipment, hand flapping) †*	2	9	23	44	23
Creates or increases positive mood†	42	50	6	0	2
Increases the quality of communication (e.g. eye contact, gesturing, conversation) †	32	50	10	6	2
Helps them to focus and pay attention†	33	46	14	5	2
Theme 2: MSEs have distinct properties that facilitate benefits					
Benefits of MSE use continue once the pupil has left the MSE	28	57	8	5	2
Using the MSE brings benefits because it is motivating for the pupil	31	58	11	0	0
Using the MSE with a pupil helps to build your relationship with them	46	47	7	0	0
Using the MSE brings benefits because the pupil can control their environment	24	56	16	2	2
Theme 3: MSE use should be centred on the child's needs					
How the MSE should be used is determined by the pupil's needs (e.g. sensory needs, learning needs)	77	23	0	0	0
I can use the MSE in the same way for each pupil and it will be beneficial*	0	5	8	39	48
The pupil's response to the room affects whether or not I use it with them	33	47	13	6	2
The MSE is more beneficial for pupils with ASD than pupils with other special needs	2	7	38	14	39
Theme 4: MSEs are most effective when the practitioner plays an active role					
I have specific goals in mind each time I use the MSE	32	47	10	8	4
Practitioner experience is essential for effective MSE sessions	42	37	15	5	1
More research is needed into the best ways to use MSEs with autistic pupils	44	40	13	3	0
The most important factor in a successful MSE session is an active practitioner working with the pupil	30	42	17	7	4

Training would benefit the way I use the MSE	61	25	10	4	1
Theme 5: MSEs can be used for teaching and learning					
The most important outcome from the MSE is that the pupil learns	7	16	21	40	17
The most important outcome from the MSE is that the pupil had fun*	18	38	20	18	7
There are teaching possibilities in the MSE not available in the classroom	49	45	2	1	3
Theme 6: MSE use can present challenges					
Leads to them becoming over-fixated on a piece of equipment†	3	26	32	25	13
Leads to them becoming over-stimulated†	1	18	33	35	13
The benefits from using the MSE could be achieved using other school activities (e.g. craft time, story telling)	11	20	16	35	19
The MSE does not always bring benefits	8	44	23	18	8

* Items are reverse worded from the theme title
† Items included in the ordinal logistic regressions

Table 2.6. Percentage agreement of each theme

Theme	%
MSEs benefit cognition, behaviour and mood*	
Overall agreement %	**85**
Strongly agree	44
Somewhat agree	40
Neither agree nor disagree	10
Somewhat disagree	4
Strongly disagree	1
MSEs have distinct properties that facilitate benefits	
Overall agreement %	**87**
Strongly agree	32
Somewhat agree	55
Neither agree nor disagree	10
Somewhat disagree	2
Strongly disagree	1
MSE use should be centred on the child's needs*	
Overall agreement %	**89**
Strongly agree	*53*
Somewhat agree	*36*
Neither agree nor disagree	*7*
Somewhat disagree	*4*
Strongly disagree	*1*
MSEs are most effective when the practitioner plays an active role	
Overall agreement %	**80**
Strongly agree	42
Somewhat agree	38
Neither agree nor disagree	13
Somewhat disagree	5
Strongly disagree	2
MSEs can be used for teaching and learning*	
Overall agreement %	**58**
Strongly agree	25
Somewhat agree	33
Neither agree nor disagree	14
Somewhat disagree	20
Strongly disagree	9
MSE use can present challenges	
Overall agreement %	**33**
Strongly agree	6
Somewhat agree	27
Neither agree nor disagree	26
Somewhat disagree	28
Strongly disagree	13

* These theme percentages sum to +/-1 over 100 due to rounding
"Overall agreement %" represents the summed percentages of "Strongly agree" and "Somewhat agree"

2.4 Discussion

The present study is the first of its kind to explore the beliefs and experiences of practitioners using MSEs with autistic children. In Study 1, interviews were conducted with ten practitioners and produced six themes: (1) MSEs promote positive outcomes for cognition, behaviour and mood, (2) MSEs have distinct properties that facilitate benefit, (3) MSE use should be centred on the child's needs, (4) MSEs are most effective when the practitioner plays an active role, (5) MSEs can be used for teaching and learning, and (6) MSE use can present some challenges. A mixed-methods approach led to Study 2, a follow-up survey of 102 practitioners. This study produced findings largely consistent with the qualitative findings. In addition, practitioners who had received training were almost four times more likely to agree that the MSE would improve focus and attention

Findings will be discussed in two sections to reflect the two primary research questions. Firstly, practitioner endorsed outcomes will be discussed by focusing on findings from themes 1, 5 and 6. Then factors practitioners highlighted as affecting outcomes will be discussed by focussing on themes 2, 3, and 4.

2.4.1 What are the beliefs and experiences of educational practitioners about the possible outcomes and overall efficacy of using MSEs with autistic children?

In the interview study the most discussed theme was that MSEs benefit cognition, behaviour and mood, and this theme was also highly endorsed by the survey respondents. The practitioners believed that the MSE could increase focus and attention, enjoyment, learning, social interaction and communication, and reduce RMBs, and challenging behaviours. The interviewed practitioners also suggested that outcomes were made possible through a reduction in anxiety. Previous interview and survey studies on MSE use with individuals with varying disabilities have reported similar outcomes, including improved enjoyment (Ayre, 1998; Bozic, 1997; Stephenson & Carter, 2011a, 2011b), learning (Ayre, 1998; Bozic, 1997; Stephenson & Carter, 2011a), relationship building (Carter & Stephenson, 2012; Stephenson & Carter, 2011a), and attention (Carter & Stephenson, 2012; Stephenson & Carter, 2011a), as well as reduced anxiety (Ayre, 1998; Stephenson & Carter, 2011a, 2011b), self-stimulatory (akin to RMBs; Carter & Stephenson, 2012) and challenging behaviours (Carter & Stephenson, 2012).

Social interaction and communication is a core autistic symptom (APA, 2013) and these difficulties can have an impact on wellbeing (e.g. Kuhlthau et al., 2010). It is therefore encouraging that practitioners believed social interaction and communication can be facilitated by MSE use. Pro-social behaviour (i.e. a type of social interaction and communication) has been measured in previous quantitative MSE studies in autistic (e.g. Fava & Strauss, 2010), and disabled (e.g. Glenn et al. 1996) populations. However, there has been little investigation of broader social interaction and communication in previous empirical studies of MSE use. This likely reflects the limited previous study of autistic populations in the MSE.

Anxiety was another outcome that the current practitioners described, in-line with previous practitioners, but anxiety has not been tested in previous quantitative studies. Anxiety symptoms are considerably higher in autism compared to the general population (Bellini, 2004) and to those with other disorders (Gillott, Furniss, & Walter, 2001; Green, Gilchrist, Burton, & Cox, 2000). Elevated anxiety levels have also been associated with atypical sensory function in autism (Gillott & Standen, 2007; Uljarevic, Lane, Kelly, & Leekam, 2016), which has led to sensory interventions being suggested as a possible means of reducing anxiety (South & Rodgers, 2017). Anxiety is also linked to core autistic symptomatology including RRBs (Rodgers, Glod, Connolly, & McConachie, 2012) and social communication impairments (for review see Kerns & Kendall, 2014). This aligns with the current practitioners' belief that reducing anxiety leads to benefits in a range of other behaviours, including core autism symptoms. The hypothesis that anxiety reduction may be a gateway to improving other behaviours has yet to be explored in the context of an MSE.

Considering that the MSE is a sensory intervention, the diagnostic relevance of sensory symptoms, and the measurement of sensory functioning in a previous MSE study (Mey et al. 2015), it was expected that the current practitioners would describe sensory behaviours as an outcome of MSE use. However, both the current practitioners and practitioners in previous studies (Carter & Stephenson, 2012; Stephenson & Carter, 2011a, 2011b) described sensory stimulation as a *property* of the MSE that enables benefits, rather than an outcome itself (e.g. sensory behaviours). This could reflect that sensory functioning is unchanged by MSE use. It is also possible that changes to sensory behaviour have been described in studies but not enough for them to be a distinct code or theme, or that they have been discussed in relation to another outcome. For example, they may be covered in discussion of RRBs.

Learning was expressed as an important outcome by the interviewed practitioners, echoed by the Australian teachers interviewed by Stephenson and Carter (2011a). This perception is endorsed by Mey et al.'s (2015) observational study of six autistic children, which found that repeated MSE use led to an improvement in learning. However, 56% of surveyed practitioners endorsed that the most important outcome from MSE use was having fun, and only 23% endorsed that the most important outcome was learning. This finding could reflect the original conception of the MSE as a tool for leisure (Hulsegge & Verheul, 1986). However, it could also reflect the question wording. Practitioners would have directly compared the importance of fun and learning in making their decision, compared to the open-ended interview questions where contrasting different outcomes was not required. Indeed, only 7% *strongly* agreed that learning was the most important outcome and only 18% *strongly* agreed that fun was the most important outcome. This suggests there may be other important outcomes that were not included in the survey or that the MSE is not considered to have a 'most important' outcome, which could reflect fundamental beliefs about MSEs or recognition of the heterogeneity of autism. It is also relevant to consider that fun and learning are not mutually exclusive, as learning can occur through fun, and fun through learning. A review of the interview transcripts showed a practitioner echoed this sentiment, "It's fun, you know, and they don't realise that they're learning when they're having fun". This quandary highlights a limitation of using surveys as it is not possible to probe intentions and interpretations post-hoc.

For both the interview and survey study there was more consensus over positive outcomes than there were about challenges of MSE use. This mirrors the field of qualitative and quantitative MSE research more generally as there has been more evidence for positive rather than negative outcomes, although there is a clear bias towards measuring positive outcomes. Only two studies discuss challenges of MSE use alongside benefits (Carter & Stephenson, 2012; Stephenson & Carter, 2011a), with Stephenson and Carter (2011a) reporting that MSEs could be distressing for some children, but that the probability of this occurring could be reduced by tailoring the session. Although this finding aligns with findings in the present study, they are the beliefs of only a few practitioners as not all agreed that there were challenges, which limits generalisability.

The majority (86%) of surveyed practitioners agreed with the interview consensus that benefits of the MSE continue once the autistic child has left the MSE, which is in-line with the findings from Ayre's (1998) qualitative study. The interviewed practitioners from the current study also provided some more nuanced insight by suggesting carry-over effects depended on the activity that followed the MSE session (e.g. calm classroom activity or outdoor play). This insight may in part explain why evidence of carry-over effects has been mixed in observational studies across different disorders (Chan et al., 2005; Kaplan et al., 2006).

2.4.2 What factors do practitioners believe may affect possible outcomes in the MSE for autistic children?

Although it is important to identify autism-relevant outcome measures, it is also important to understand factors that can affect such outcomes so that MSEs can be used for maximum benefit. MSEs were described and highly endorsed as having distinct properties that facilitate benefit, which included the MSE enabling the control of the sensory environment. This was discussed by the interviewed practitioners as a way of reducing challenging behaviours and increasing adaptive behaviours and was endorsed by 80% of surveyed practitioners. This belief is shared by practitioners in other qualitative studies (Ayre, 1998; Stephenson & Carter, 2011a), and having control of the MSE is a central theory of why MSEs may be beneficial (Eijgendaal et al., 2010; Glenn et al., 1996; Hirstwood & Smith, 1996; Moore et al., 1994). However, these previous findings and theories have not been specific to autism. Therefore, this is the first study to report that control of the MSE is perceived as important for autistic children. Importantly, control of the sensory environment may better enable autistic individuals to regulate their sensory needs and achieve sensory comfort, enabling better engagement with the wider environment. Another explanation could be related to autistic individuals having a higher than usual intolerance of uncertainty (IoU), which is associated with anxiety (Boulter, Freeston, South, & Rodgers, 2014; Neil, Olsson, & Pellicano, 2016). IoU has been described as the increased perception of ambiguity, along with increased discomfort from it (Dugas, Gagnon, Ladouceur, & Freeston, 1998). Boulter et al. (2014) present a model suggesting that IoU and anxiety play a role in some of the core symptoms of autism. Within this model, sensory sensitivity impacts IoU, and this in turn leads to anxiety and RRBs, which also impact each other. Therefore, it is conceivable that through having control of their sensory environment, sensory stimulation becomes predictable for autistic children, and this reduces uncertainty, leading to a reduction in anxiety and RRBs.

Another theory that supports the practitioner's assertion that being in control may lead to positive outcomes is Bayesian predictive coding theory (e.g. Pellicano & Burr, 2012). Within this theory, priors are formed based on prior experience and statistical regularities of the sensory environment, providing expectations about the sensory world. Priors are compared to incoming sensory input and if they are found to be similar, the sensory input is not processed further, reducing neural load. That is, the smaller the differences between the sensory input and what was expected based on the priors, the lower the prediction error. In autism, priors are suggested to be more uncertain and less precise, with the environment being perceived as more unpredictable than it actually is (e.g. Lawson, Mathys, & Rees, 2017), leading to RRBs and feelings of being overwhelmed (Pellicano & Burr, 2012). However, when the autistic child has control in the MSE, the sensory changes are expected (i.e. making the environment less unpredictable), lowering prediction error, reducing neural load and endorsing behaviour changes. An alternative, although not mutually exclusive interpretation, is that simply feeling in control enables benefits, as feeling in control is suggested to play an integral role in the general well-being of children (Fattore, Mason, & Watson, 2007; Fattore, Mason, Watson, Mason, & Watson, 2009; Larson, 1989).

Practitioners also described that the MSE was motivating for autistic children and that this enabled benefits. This was also described by Stephenson and Carter's (2011a, 2011b) practitioners in reference to MSE use with children with varying disabilities. One practitioner within the present study suggested that this was particularly important because finding preferred objects to motivate autistic children can be difficult. Indeed, Koegel and Egel (1979), in a non-MSE study, reported that their autistic sample lacked motivation and this negatively impacted on their learning. Therefore, future studies should investigate preferred objects within an MSE, in order to provide practitioners with information on motivating stimuli that can be used to enable better outcomes. This issue will be returned to in Chapter 5, where preferred equipment is investigated.

Interviewed practitioners also stated that the child's needs, capabilities and preferences determined whether the MSE was used, how MSEs should be used, and what the benefits could be. Versions of these statements were strongly endorsed by the survey respondents, with 100% agreeing that how the MSE is used is determined by the pupil's needs. Indeed, the theme was the most highly endorsed of all themes by the survey respondents. The importance of tailoring MSE use to the child's needs was also described by the practitioners that Stephenson and Carter (2011a) interviewed. Developing what was found in the current study, the broader literature implies that there are two primary ways of tailoring MSE use to the child's needs. For the first method, the child has needs met by tailoring the MSE *themselves* (i.e. switching lights on and off rapidly to gain visual stimulation). This approach has been previously advocated for in the literature (e.g. Ayre, 1998) and is in-line with the original method of MSE use, Snoezelen® (Hulsegge & Verheul, 1986). It is also related to the sub-theme of control from the interview study, where the practitioners stated that needs are met and benefits occur when the child tailors their own sensory experience through having control. For the second method, the *practitioner* tailors the MSE use to the child's needs to meet particular goals. This is similar to Bozic's (1997) developmental repertoire, where the child is led by the practitioner to enable positive outcomes. This method is also in-line with the current practitioners' emphasis on the importance of an active practitioner. However, within the qualitative literature opinions on this topic are varied (Pagliano, 1998; Stephenson & Carter, 2011a). The majority of Stephenson and Carter's (2011a) practitioners believed that MSEs had an automatic effect without the practitioner engaging, and some of Pagliano's (1998) practitioners also advocated for this belief. As these studies were both on Australian practitioners these differing findings could suggest cultural differences, with passive use of the MSE not being prominent in UK educational settings. Alternatively, the current interviewed practitioners may have had a broader definition of 'active' compared to previously interviewed practitioners.

More broadly speaking, the importance of tailoring the MSE session to the child's needs is in accordance with current special education statutory guidance to assess individual needs, implement tailored provisions, and monitor outcomes (Department for Education, 2015). Individualised Education Plans (IEPs, also known as Individualised Learning Plans) and Goal Attainment Scoring (GAS; Kiresuk & Sherman, 1968), which can be used to map the progress of IEPs (Ruble, Mcgrew, & Toland, 2012), have been used to implement the statutory guidance. IEPs aim to individualise a special educational curriculum to the specific needs of a child. Likewise, GAS, created over 40 years ago for use in mental health settings (Kiresuk & Sherman, 1968), has since been adopted into special education settings (e.g. Oren & Ogletree, 2000), and enables the identification and measurement of specific goals for each child. GAS has been described as beneficial for use with autistic individuals (Ruble et al., 2012) considering the heterogeneity within the disorder. Therefore, the overarching frameworks of IEPs and GAS have therefore perhaps influenced the experiences and perspectives of the practitioner.

The impact of MSE training and experience

The interviewed practitioners in this study and many studies within the field have called for more training for practitioners in MSE use (Baillon et al., 2002; Carter & Stephenson, 2012; McKee et al., 2007; Mount & Cavet, 1995; Stephenson & Carter, 2011a). However, to date no study has investigated if training or years of experience affects practitioners' perceptions of the benefits of MSE use. The present study found no effect of years of experience on the perception of positive outcomes. However, whilst controlling for years of experience, it was found that MSE training made practitioners over three times more likely believe they had experienced better focus and attention in their pupils in the MSE. Therefore, training could have enabled the practitioners to foster better focus and attention in their pupils within the MSE, or alternatively it could make them better attuned to changes in focus and attention or place more value on them as possible outcomes. Although they did not withstand Bonferroni correction, those with training were also more likely to agree that the MSE makes autistic children more likely to communicate and increase the quality of that communication. It must be noted that more of the OLRs found that there was no difference in responses according to training or years of experience. However, the consistent finding of positive effects of training, rather than years of experience, suggests there is a specific value to training.

Limitations

The findings are generally positive about the use of MSEs for autistic children and provide novel insight from UK-based practitioners. However, these are the subjective beliefs and experiences of practitioners and, by design, do not provide objective evidence of the effects that the practitioners describe. A complete understanding of the use of MSEs with autistic children requires the convergence of subjective reports with objective evidence and therefore, considering the findings of this study alongside those from the quantitative study in Chapter 4 is important.

It is also acknowledged that this research did not directly ask autistic children about their experiences of MSE use. This is unfortunate as the autistic experience should not just be extrapolated from other people's experiences, but should include the direct voice of autistic people (e.g. Fletcher-Watson et al., 2019; see also Chapter 4-6). Considering that MSEs are most regularly used with lower-intellectually functioning autistic individuals, who can have minimal verbal communication, appropriate methods must be implemented to research their beliefs. For example, using the picture exchange communication system (PECS; Bondy & Frost, 1994).

Within the survey, years of experience was a general measure of how long the practitioners had worked with autistic children in MSEs but did not include how *often* they used the MSE across those years. This may have reduced the sensitivity of the years variable. Interpretation of the OLRs is also limited as no information on the type, quality and amount of training received was available.

MSEs are prominent in special-needs schools in the UK yet, there are other settings where individuals of varying ages access them. This research has not explored the beliefs and experiences of autistic adults nor has it explored the effect of MSE use in other, non-educational, settings. It is possible that the outcomes of the MSE and beliefs about methods of use may vary from these present findings depending on the setting of the MSE. For example, Ayre (1998), in an interview study, found that MSEs were used for relaxation and leisure in residential settings and hospitals, and to promote child development and education in school settings. Therefore, even though the present findings provide novel insight into the use of MSEs with autistic children in schools, the findings cannot be extended to other settings with other participants.

Conclusion

This was the first mixed methods study to investigate practitioner beliefs about MSE use specifically with autistic children. Practitioners believed the MSE had beneficial effects on core autistic symptoms, including social interaction and communication, and RMBs. Furthermore, the findings suggest that MSE use could benefit mood (particularly a reduction in anxiety), focus and attention, learning, and relationships with the practitioner and peers. However, it emerged that certain criteria needed to be met to help facilitate these positive changes, including the child having control of the MSE.

In the remainder of this thesis the current findings will be drawn upon to design two quantitative studies. In Chapter 4 the impact of the child having control of the MSE on the positive outcomes suggested by practitioners in the interview study will be investigated. This experiment will be tightly controlled to enable robust empirical findings. In Chapter 5 a more ecological approach will be taken investigating autistic children’s natural preferences for sensory equipment within the MSE in an unstructured ‘free play’ setting. This will provide valuable and novel insight into autistic children’s natural engagement patterns in an MSE. However, first, Chapter 3 will describe the process of designing of the MSE and outcome measures for use in the Chapter 4 study.

Chapter 3: Designing the MSE and the behavioural observation coding schemes

3.1 Designing an MSE at the Cardiff University Centre for Human Developmental Science (CUCHDS)

Before applying for the PhD, KU recognised the wide use of MSEs with autistic children but noted the limited evidence to advocate and facilitate their use. Therefore, KU approached Mike Ayres, the founder and director of Mike Ayres Design, a UK based MSE design and installation company, with a proposal to conduct this research. After Mike Ayres Design agreed to sponsor an MSE, KU accepted a PhD position at Cardiff University and plans were made for the MSE to be installed in CUCHDS, becoming the property of Cardiff University. The research sponsorship agreement specified Cardiff University would have complete independence over the research design, analysis and publications resulting from the research.

3.1.1 Equipment selection

It was important that the MSE was appropriate not only for research, but that it was typical of MSEs used in practice. MSE research is usually conducted in community MSEs (e.g. MSEs in residential homes, Cuvo et al., 2001, or schools, Houghton et al., 1998), therefore, the literature was surveyed to assess the contents of these ecologically valid MSEs (Table 3.1). In addition to this, the contents of the MSEs from the interview (Study 1, Chapter 2, Table 2.1) and survey (Study 2, Chapter 2, Table 2.4) studies were also considered. Therefore, across the three sources of data, the following equipment was present in ≥ 46% of MSEs: bubble tube, fibre optics, projector, CD player, coloured room lights. In addition, the mirror ball and tactile wall or floor items was present in ≥ 57% of MSEs in the two UK samples described in Chapter 2.

These most popular items were all selected for inclusion in the MSE at CUCHDS. As the CD player was the only auditory piece of equipment, other auditory items were purchased including touch, sound, and light board, and voice changer. Touch, sound and light boards (or similar items) were included in 23% of previous studies and were in 50% of interviewed practitioners' schools and 44% of surveyed practitioners' schools. The final purchased equipment is included in Table 3.2, with specifications that were important for experimental design of the Chapter 4 study such as whether items could be operated by an app through WiFi.

Table 3.1. The contents of Multi-Sensory Environments (MSEs) used in previous research

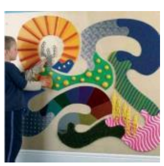
Author	Dimensions (m)	Bubble tube	Fibre optics	Projector	CD player	Bean bag	Coloured lights	Mirror ball	Tactile board	Aroma equipment or wall	Bed or mat	Mirrors	Sound light wall	Rocking chair	Colour wheel	Black light	Vibrating pillow	Vibrating floor or mat	Floor lights	Lava lamp	Other
Percentage of MSEs with item		85	85	69	69	62	46	46	38	38	38	23	23	23	23	15	15	15	15	15	
Ashby (1995), Lindsey et al. (1997), (2001)*‡	Not reported	√	√	√	√		√		√	√		√									
Chan et al. (2005)	28x28	√	√	√		√		√	√	√			√		√						Catherine wheel, glow panel, musical hopscotch pad, massage pillow, and a sensory ball
Chan et al. (2017)	Not reported		√	√				√		√											Vibrating chair
Cuvo et al. (2001)	7.01x6.71	√	√	√	√	√								√	√		√	√		√	Net with lights, and a fan
Fava et al. (2010)	9x7.5	√	√	√	√	√			√					√	√		√			√	Coloured lights ball, texture books and rain stick
Glenn et al. (1996)	Not reported	√	√				√		√		√							√			Ball pool, plasma ball, soft play equipment and hammock
Hill et al. (2012)‡	4.15x3.8	√			√		√	√													

Houghton et al. (1998)‡	Not reported	√	√	√	√		√		√		√	√	√						√	
Kaplan et al. (2006)	Not reported	√	√	√		√	√						√	√		√			√	
Martin et al. (1998)‡	6.5x4.5	√	√		√	√					√									
McKee et al. (2007)	5.49x3.66	√	√	√	√	√		√		√						√				UV wands and an electronic aquarium
Mey et al. (2015)	Not reported	√		√	√	√		√			√									Pillows
Singh et al. (2004)	7x7		√		√	√	√	√		√	√	√								Laser light show devices and various seating

Note: 2 out of the 19 studies included in this thesis (including the 17 studies in the Chapter 1 table and an additional 2 studies on MSE preference in Chapter 5) did not provided equipment lists for the MSEs they used (Shapiro et al. 1997; Thompson & Martin, 1994). Novakovic et al. (2019) did provide an equipment list, but this study was published after the installation of the MSE at CUCHDS, therefore, their equipment is not included here; *Ashby et al. (1995), Lindsay et al. (1997) and Lindsay et al. (2001) used the same MSE therefore, they are combined in this table; ‡ Authors state that the list of equipment is not exhaustive.

Table 3.2. Items included in the Cardiff University Centre for Human Developmental Science (CUCHDS) Multi-Sensory Environment (MSE)

Item	**Picture**	**Description**	**Is it interactive?**	**Can it change without interaction?**	**S4 app operated‡**	**What elements of the equipment can be interacted with?**	**Modality**
Bubble tube		The tube is filled with water and bubbles travel up the tube continuously. The water can be changed to be one of eight colours	Yes	Yes - passive setting where colours are cycled through	Yes	- Equipment on and off - Colour	Primary: Visual Secondary: Auditory (buzz of bubble motor) and Tactile (vibration of tube from motor)
Colour changing room lights		Lights which change the whole colour of the room to be one of, or multiple combinations of eight colours	Yes	Yes - passive setting where colours are cycled through	Yes	- Equipment on and off - Colour	Visual
Fibre optics		Fibre optic cabling is attached to a light box. The colour of the cabling can be changed to be one of eight colours	Yes	Yes - passive setting where colours are cycled through	Yes	- Equipment on and off - Colour	Primary: Visual Secondary: Tactile
Touch, sound & light board		Board contains eight buttons and responds to touch. When touched it produces a coloured light and can produce a sound. Eight interactive and passive activities are possible. The passive mode will run through the colour series	Yes	Yes - passive setting where colours are cycled through	No	- Buttons (colour dots) being on or off	Primary: Visual Secondary: Tactile (button press) & Auditory (makes sound as a reward)

Voice changer		This is a sound system that has inbuilt programmes which can change the audio input into different sounds e.g. "squeaky mouse" and "thunderous giant"	Yes	No	No	Sound	Primary: Auditory Secondary: Tactile (from holding microphone)
Mirror ball		Pin spotlight shines on the spinning mirrored surface of the ball and subsequently small lights are projected onto the walls	Yes	Yes - passive setting where colours are cycled through	Yes	- Equipment on and off	Visual
Projector		Projects effects or pictures onto a surface using a selected effect or picture wheel	Yes	No	Yes	- Equipment on and off	Visual
Tactile disks		Different textured floor disks. Each set contains 5 large and 5 small (hand size) disks	No	No	No	None	Primary: Tactile Secondary: Visual
Sound system		Sound system to play music	Yes	No	No	- Equipment on and off	Auditory
Tactile wall		Wall panel with different materials that have different textures	No	No	No	None	Primary: Tactile Secondary: Visual

‡ S4 app is the app designed by Mike Ayres Design to operate the WiFi enabled MSE equipment

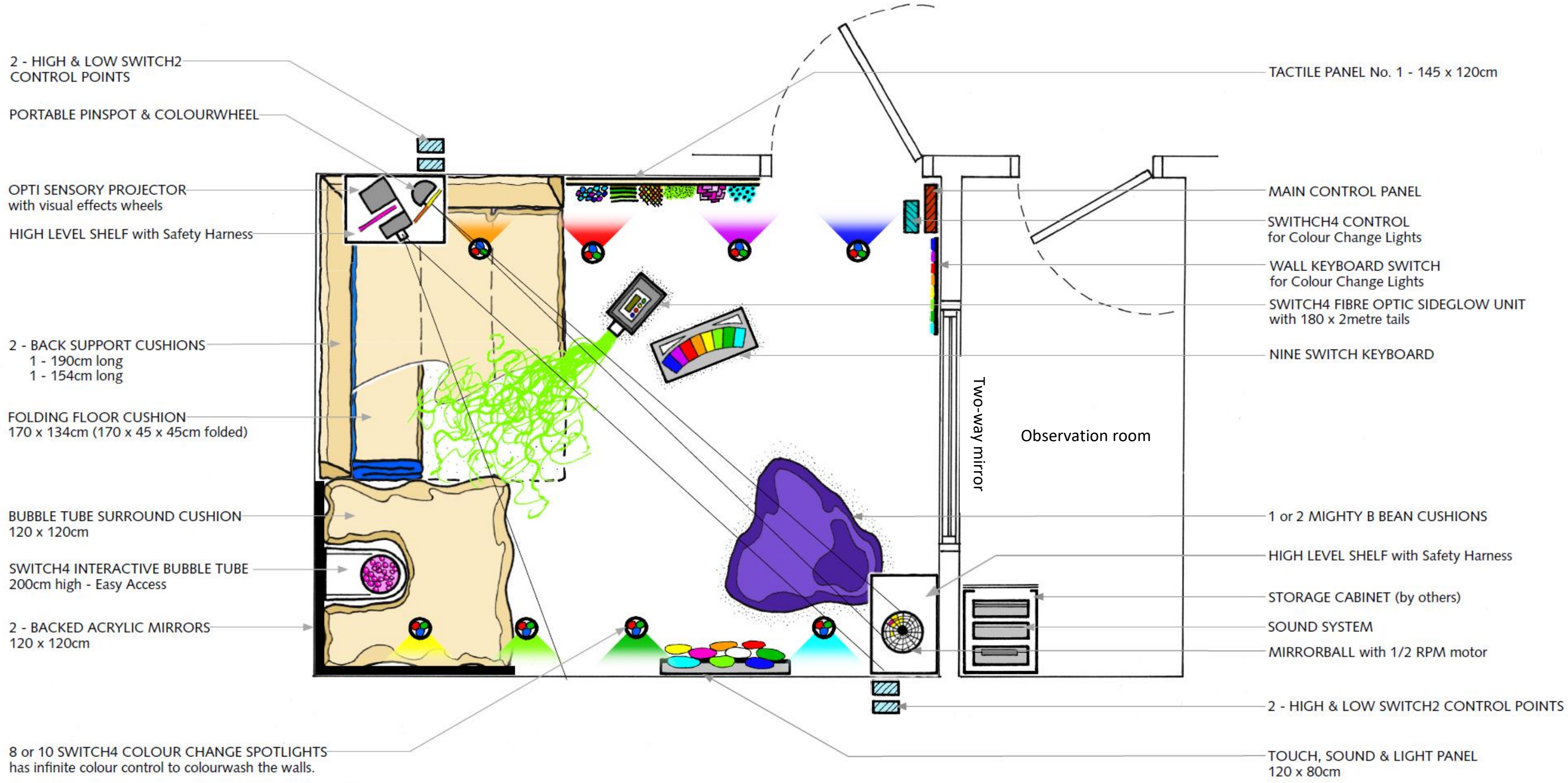
3.1.2 Room selection

Mike Ayres Design advised that an ideal room for an MSE should include no external windows, minimal noise disturbance and be an appropriate size for the necessary equipment. It should also have minimal additional features, for example, unobtrusive power sockets. In addition to this, an adjoining room was also necessary to create an observation suite. A suitable room (3.15 x 3.95 metres), previously assigned as a generic testing space, was identified that met these criteria. Mike Ayres Design designed the layout of the chosen equipment (Figure 3.1, next page).

To prepare the room for use, a two-way mirror was installed to enable an observation suite. Following Mike Ayres Design specifications, the room was painted in matt ivory emulsion (BS10-B-15), and the floors were carpeted in blue (company: Westbond - 9240 “Wedgewood”). The isolator switch (to disconnect all electronic equipment) was out of reach of children. Power and ethernet sockets were kept to a minimum, and truncation was removed from walls. The preparation of the room was completed in July 2017 (Figure 3.2).

Figure 3.2. Pictures of the Multi-Sensory Environment (MSE) room before the equipment was installed

Figure 3.1. Mike Ayres Design schematic of the Multi-Sensory Environment (MSE) at the Cardiff University Centre for Human Developmental Science (CUCHDS; adapted and used with permission from Mike Ayres)



The equipment was professionally installed in August 2017 (Figure 3.3). A timeline of the MSE installation process and study is included in Appendix C.

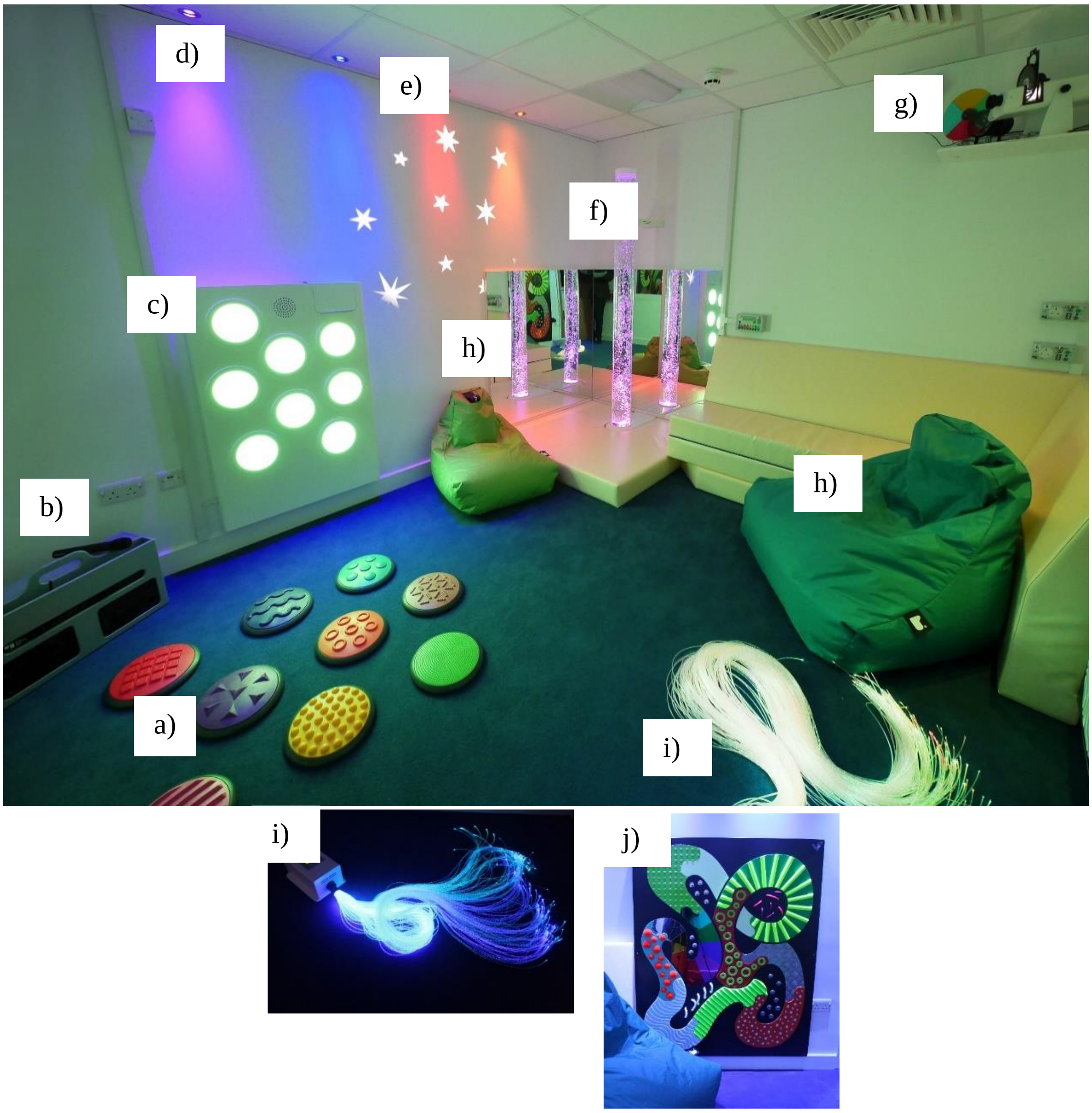


Figure 3.3. Pictures of the installed Multi-Sensory Environment at the Cardiff University Centre for Human Developmental Science (CUCHDS). TOP: a) Tactile floor pads, b) voice changer, c) touch sound and light board, d) rainbow LED room lights, e) projected scene from adjacent projector, f) bubble tube, g) pin-spot for adjacent mirror ball, h) bean bags, i) fibre optics, j) tactile wall.

3.2 The selection of outcomes and development of behavioural observation schemes for the study of autistic children's behaviour in an MSE (Chapter 4)

3.2.1 Selecting outcomes

For the study in Chapter 4, outcomes relevant for measuring the effect of the MSE on autistic children were needed. The following outcomes were identified through the studies in Chapter 2: social interaction and communication, relationship quality, anxiety, enjoyment, focus and attention, RMBs, learning, and challenging behaviours. These outcomes were then considered alongside outcomes used in previous MSE studies (Chapter 1, Table 1.3), of which some were not specifically on autistic individuals, to guide development of specific outcome measures to be used in the Chapter 4 study.

The practitioners did not describe sensory behaviours as an outcome. However, a previous MSE study on autistic children measured sensory functioning (Mey et al. 2015). Considering also that the MSE is a sensory intervention, and sensory functioning was added to the DSM-5 criteria for autism in 2013, sensory behaviours were included here.

Challenging behaviours were described as possible outcomes by some, but not all interviewed practitioners, and on average only 24% of surveyed practitioners endorsed that the two challenging behaviours included in the survey were possible. Ultimately the safety protocol of the study dictated that the testing session would need to be terminated if a participant displayed challenging behaviours, so this was not included as an outcome measure.

Finally, the practitioners stated that learning was possible in the MSE, yet the surveyed practitioners did not highly endorse this outcome. Also, as the study aims to recruit participants with a range of abilities, the learning outcomes would have to be defined individually which is not pragmatic for this study. Therefore, learning was not included as an outcome.

The final selected outcome variables were **social interaction and communication** (including **relationship quality**), **anxiety, enjoyment, attention, RMBs,** and **sensory behaviours**. Variations of these measures have been used in other studies, although some measures have differing names (e.g. RMBs were termed 'stereotypic self-stimulatory behaviour' in previous MSE studies; see Table 1.3 in Chapter 1 and Discussion in Chapter 2).

3.2.2 Developing study specific behavioural observation schemes

Previous MSE studies and the broader observational literature were used to devise coding schemes appropriate for the current study (Chapter 4). The full observation coding schemes for all measures included in this study can be found in Appendix D. Most measures used frequency coding of behaviours, or frequency and duration where appropriate. A further subset used Likert scales as overall global scores.

3.2.2.1 Social interaction and communication: Social behaviour, gesture, mimicry, rapport and speech

Some previous MSE studies have measured social interaction and communication within a broader adaptive behaviour measure (BC; Shapiro et al. 1997; also used by Chan et al. 2005, Chan & Chien 2017, Table 1.3), whilst others have used more specific social measures (Fava & Strauss, 2010; Glenn et al., 1996; Lindsay et al., 2001), some of which were individually defined for specific participants (McKee et al., 2007; Mey et al., 2015). Although, these measures only measured small facets of social interaction and communication (i.e. adaptive and pro-social behaviour). Therefore, versions of these codes were integrated into the present, more detailed measure, including verbalises/vocalises (Chan & Chien, 2017; Chan et al. 2005; Lindsay et al., 2001; Shapiro et al., 1997), and initiating interaction (Glenn et al., 1996).

ADOS-2 (Lord et al., 2012) codes were chosen for the present study as it is the gold-standard observation tool to aid in the diagnosis of autism (Shumway, Farmer, Thurm, Joseph, & Black, 2012) and its codes are often used in observational coding schemes (e.g. Brief Observation of Social Communication Change, BOSCC; Grzadzinski et al., 2016). The final scheme included five types of social behaviour, four gestures, two types of mimicry, two types of speech, and a global measure of rapport (listed in Table 3.3), all of which were derived directly from the ADOS-2, except for the division of mimicry behaviours into "full" and "partial", which was added to gain further detail about mimicry. There were also some minor changes to definition wording to ensure clarity. Some behaviours from the ADOS-2 were excluded as they either required the administration of a specific task (e.g. "Response to name") or the camera equipment could not capture micro-behaviours such as eye contact. In addition, Fusaro, Harris, and Pan's (2011) paper on gestures informed the inclusion of "shrugging" and "nodding" as conventional gestures.

The ADOS-2 coding was originally designed to classify a range of social behaviours by degree of impairment on a descriptive 0-3 scale (sometimes 0-2), with each increasing number referring to a quantifiably more atypical social presentation. In the current study, preference was for a simpler coding of presence/absence of behaviour (i.e. frequency). This was partly to support reliable coding and also to align with coding of other types of behaviour (e.g. RMBs). Duration of speech (s) was also coded. As in the ADOS-2, rapport was distinct from the other codes as a subjective judgement about relationship quality with the experimenter across the entire testing session. Therefore, the 0-3 global rating was used for rapport coding.

Table 3.3. Codes included in the social interaction and communication measure

Code type	Codes
Social behaviour	Showing Requesting Offering information Asks for information Shared enjoyment
Gesture	Conventional Informational Emphatic/beats Deictic
Mimicry	Full mimic Partial mimic
Speech	Speech (any speech that is not stereotyped/idiosyncratic) Stereotyped/idiosyncratic speech (including immediate echolalia)
Rapport	Rapport

3.2.2.2 Anxiety

Previous MSE studies have not included a specific measure of anxiety so the broader literature was surveyed to identify relevant anxiety measures. The Preschool Observation Scale of Anxiety (POSA; Glennon & Weisz, 1978) contained a wide range of anxiety symptoms derived from 17 empirical studies of anxiety behaviour in children. It could not be used in its entirety as some behaviours overlapped with the RMB measure and, at 30 items, was too long to be used in its entirety. The anxiety observation measure was therefore derived by looking across a range of other anxiety measures to find the most endorsed and suitable items from the POSA. Anxiety items not included in the POSA were also considered.

The final measure included items from the POSA and ADOS-2, and also from some well validated questionnaires including, the Screen for Child Anxiety Related Disorders (SCARED; Birmaher et al., 1999), Spence's Children's Anxiety Scale (SCAS; Spence, 1999), Paediatric Anxiety Rating Scale (PARS; Riddle, 2002), and Anxiety Scale for Children-ASD (ASC-ASD; Rodgers et al., 2016). Papers describing anxiety related symptoms in children were also used to refine definitions (Dougherty et al., 2015, 2013; Stringaris, 2011; Valle Krieger, Leibenluft, Stringaris, & Polanczyk, 2013). Items from these measures were not considered if they were not codable behaviours (e.g. 'My child is afraid of entering a room full of people', ASC-ASD, Rodgers et al. 2016), if the item was a micro-behaviour that would not be reliably visible on the coding videos (e.g. 'Lip trembling', POSA, Glennon & Weisz, 1978), or if items were situation specific (e.g. 'My child worries about going to school', SCARED, Birmaher et al, 1999). The final coding scheme consisted of ten behaviours to be frequency coded (Table 3.4).

Table 3.4. Codes included in the anxiety measure

Codes
Whine or whimper[1]
Stutter[1]
Trembling/shaking body or voice[1 2 3 4 5 6]
Jumpiness[2]
Body contortions or rigid posture[1 6]
Physical complaint[1 4 5 6]
Desire to leave[1 6]
Expression of fear or worry[1 2]
Crying[1 2 6]
Irritability[6 7 8 9 10]

Measures or papers that the anxiety codes were drawn from:
[1] Preschool Observation Scale of Anxiety (POSA; Glennon et al 1978)
[2] Autism Diagnostic Observation Schedule 2 (ADOS-2; Lord et al 2012)
[3] Anxiety Scale for Children- ASD (ASC-ASD, Rodgers et al 2016)
[4] Screen for Child Anxiety Related Disorders (SCARED; Birmaher et al 1999)
[5] Spence Children's Anxiety Scale-Parent (SCAS; Spence et al 2000)
[6] Paediatric Anxiety Rating Scale (PARS; Riddle et al 1997)
[7] Dougherty et al (2015)
[8] Dougherty et al (2013)
[9] Stringaris (2011)
[10] Valle Krieger et al (2013)

In addition to the frequency coding, to get a broader overview of the quality and pervasiveness of anxiety, a global coding scheme was also devised using the ADOS-2 style of coding. This measure aimed to capture the overall perceived severity and persistence of anxiety at each piece of equipment and across the whole session, with the rating from 0 to 2, where:

0 = No anxious behaviour or mild and occasional presentation

1 = Anxious behaviours that are mild but persistent, or marked anxiety behaviours that are occasional

2 = Marked anxiety behaviours that are persistent

3.2.2.3 Enjoyment

In previous MSE studies enjoyment has been rated, but either no specific behaviour markers were described (e.g. 'happy' in Chan et al. 2005, or 'no enjoyment' in Lindsay et al. 1997), or only a small number of behaviours were included (e.g. only 'smiling' and 'happy noises' in Glenn et al. 1996). Therefore, none of these in their entirety were appropriate for the present study, yet, two common items from these measures, 'smiling' and 'laughing', that were also used in Harter (1974), were included in the present measure.

As facial expressions are often diminished in autism (e.g. Yirmiya, Kasari, Sigman, & Mundy, 1989), it was decided that the present measure needed to incorporate non-facial codes, and therefore, 'verbal expressions of enjoyment' and 'integrated singing and dancing' (e.g. Saarikallio, 2010) were included. A decision was made that singing and dancing had to be integrated for it to be coded in order to prevent interpreting ambiguous body movement as dancing (Murcia, Kreutz, Clift, & Bongard, 2010).

The final enjoyment measure included coding the frequency of ‘smiling’, ‘laughing’, ‘verbal expressions of enjoyment’ and ‘integrated singing and dancing’. Additionally, a measure of overall presentation of enjoyment across the whole session was included, similar to the global anxiety coding on a scale of 0-2:

0 = No or mild and occasional enjoyment is shown

1 = Enjoyment behaviours that are mild but persistent, or marked enjoyment behaviours that are occasional

2 = Marked enjoyment behaviours that are persistent – such that you can say the child had fun (must be unambiguous enjoyment)

3.2.2.4 Attention

Previous MSE studies measured attention as the frequency of physical contact with task objects (Cuvo et al., 2001; Glenn et al., 1996; Hill et al., 2012; Martin et al., 1998), meaningful movements within a task (Ashby et al., 1995; Lindsay et al., 1997), prompts that the participant required to complete a task (Kaplan et al., 2006), and unspecified codes individualised to the participants (Mey et al., 2015). A common element of many of these coding schemes is the measurement of on-task behaviour. Indeed, coding schemes used in the broader attention literature also use the coding of on-task behaviours (e.g. Peterson, Swing, Stark, & Waas, 1984), along with the coding of off-task behaviours (e.g. Abikoff, Gittelman-Klein, & Klein, 1977; Peterson et al., 1984). Therefore, measurement of off-task behaviour (i.e. distractibility) and on-task behaviours (i.e. attention) will be measured in the present study to fully capture attention.

Attention is difficult to measure reliably as the onset and offset of attention is not always behaviourally obvious, and the *quality* of attention cannot be quantified through frequency coding. However, a global rating allows for a qualitative appraisal of attention that is arguably more accurate as ambiguous periods of attention can be discounted, and quality of attention can be considered. Other studies of attention (e.g. Reed & Edelbrock, 1983) and the ADOS-2 (Lord et al., 2012) also use global coding to measure attention, therefore, it was decided that global coding would be used here. The global coding was designed to provide an overview of the *quality* of attention through the consideration of both on-task and off-task behaviours, on a scale of 0-2. The definitions of on-task and off-task behaviour were devised based on codes used in previous MSE studies (e.g. touching objects, Cuvo et al. 2001; looking at objects, Hill et al. 2012), and observations of behaviour during piloting:

Definition of “on-task”:

> During the MSE session the child is encouraged to pay attention to each piece of equipment for three minutes as directed by the experimenter. This can include touching and looking at or using the equipment or the iPad (control only).

Definition of “off-task”:

> Being off-task includes the child not touching or looking (directly or indirectly) at the equipment (including iPad) that they are encouraged to pay attention to. Being off-task may include physically turning away or being physically present but persistently looking away from the equipment.

0 = The child remains on-task (i.e. at the necessary piece of equipment) throughout the 3-minutes

1 = The child shows distraction at times but spends only a small amount of time off-task (i.e. more time is spent on-task than off-task)

2 = The child shows distraction consistently and spends a large amount of time off-task (i.e. more time is spent off-task than on-task)

An attention score between 0 and 2 was to be assigned at the touch, sound and light board, bubble tube and fibre optics in each condition. Attention could not be coded at the other pieces of equipment (i.e. mirror ball and room lights) as the child was not required to remain in one place for these equipment as they affected sensory change in the whole MSE rather than just in one location. An average of these three scores in each condition was then calculated to give an overall attention score.

3.2.2.5 Repetitive Motor Behaviours (RMBs)

Previous MSE studies investigating RMBs all measured similar behaviours, but in different ways. Three studies used the stereotypical behaviour sub-scale of the BC (Shapiro et al. 1997, also used by Chan et al. 2005, Chan & Chien 2017), and the other five studies either used measures individualised to their participants (Cuvo et al. 2001) or to their specific study design (Fava & Strauss, 2009, Glenn et al. 1996, Hill et al. 2012, Martin et al. 1998). As such, none of these schemes could be used in their entirety but versions of appropriate codes from them were included in the present measure (e.g. ‘flaps hands’ from the BC forms part of the hand/finger/foot code). Some codes were not included as they would be coded under other schemes in the present study (e.g. ‘eats, sucks clothes’; BC, Shapiro et al. 1997 - coded under sensory).

The other source of information in devising the RMB scheme was RRB questionnaires. The Repetitive Behaviour Scale-Revised (RBS-R, Bodfish, Symons, Parker, & Lewis, 2000) groups

RMBs into categories including whole-body, hand/finger and locomotion, groupings that are not explicit but are also evident in the RBQ-2 (Leekam et al. 2007). All three categories were included in the present measure. The definitions of these three categories of RMBs were devised using the RBS-R, RBQ-2 and previous MSE studies. One addition made to the RBS-R categories was broadening the hand/finger category to include repetitive foot movements, in-line with previous MSE studies (e.g. Hill et al. 2012). Items from the RBS-R and RBQ-2 not included in the present measure were those related to insistence on sameness, as these are a separate type of RRBs, and sensory items, as they were included in separate scheme.

In line with the RBQ-2, both frequency and duration of whole body, hand/finger/foot and locomotive repetitive behaviours were coded.

3.2.2.6 Sensory behaviours

Mey et al. (2015) was the only MSE study to measure sensory behaviour but they did not provide adequate details of their coding scheme. Indeed, published sensory observation measures could also not be used here as they all require the administration of specific tasks (Sensory Processing Assessment, SPA; Baranek, 1999; Sensory Assessment for Neurodevelopmental Disorders, SAND; Siper, Kolevzon, Wang, Buxbaum, & Tavassoli, 2017; Autism Diagnostic Observation Schedule, ADOS-2, Lord et al. 2012). As such, a sensory observation measure was created for this study inspired by the DSM-5 (APA, 2013), observation measures (SPA, Baranek, 1999; SAND, Siper et al. 2017; ADOS-2, Lord et al. 2012), and questionnaires of sensory processing (Sensory Experiences Questionnaire, SEQ, Baranek, 1999; Sensory Profile, SP, Dunn, 1999; Glasgow Sensory Questionnaire, GSQ, Robertson & Simmons, 2013).

The DSM-5 classifies sensory issues in autism by types of response to sensory input including hyper-reactivity, hypo-reactivity and sensory seeking (APA, 2013). Hyper-reactivity has been described as over-reactivity to sensory stimuli (e.g. Lane et al. 2010) and can be measured by recording defensive behaviours that reduce sensory input (e.g. Baranek et al. 2018). Hypo-reactivity is the absence of response to sensory stimuli (Baranek et al., 2006), which meant it was not possible to reliably code in the current study. Sensory seeking is the active seeking of sensory stimulation (e.g. Lane et al. 2010). Sensory questionnaires further categorise sensory behaviours by a range of modalities (e.g. auditory, tactile, visual, gustatory, olfactory, vestibular and proprioceptive; SEQ, Baranek, 1999a; SP, Dunn, 1999; GSQ, Robertson & Simmons, 2013). In contrast, the observation measures only include three: auditory, tactile and visual (SPA, Baranek, 1999; SAND, Siper et al. 2017; ADOS-2, Lord et al. 2012). Siper et al. (2017) stated that this is because the evidence base for these three modalities is more substantial in autism and the other modalities are difficult to measure within observational settings. Therefore, the current measure included sensory defensive and seeking behaviours across the auditory, tactile and visual modalities (Table 3.5). The individual behaviours included in these categories were derived from the measures described above with the addition of experimental papers (Baranek et al., 2018; Lane et al., 2010). As with the coding of RMBs, frequency and duration of sensory behaviours were coded.

Table 3.5. Codes included in the sensory measure

Sensory coding
Defensive Visual [1 2 3]
Defensive Auditory [1 2 3 5]
Defensive Tactile [1 2 3]
Seeking Visual [2 3 4]
Seeking Auditory [2 3 4]
Seeking Tactile [2 3 4]

[1] Sensory Processing Assessment (SPA, Baranek, 1999)
[2] Sensory Assessment of Neurodevelopmental Disorders (SAND, Siper et al., 2017)
[3] Autism Diagnostic Observation Schedule (ADOS-2, Lord et al., 2012)
[4] Baranek et al. (2018)
[5] Lane et al. (2010)
Items were also generally informed by the Glasgow Sensory Questionnaire (GSQ, Robertson & Simmons, 2013), Sensory Experiences Questionnaire (SEQ, Baranek et al., 2006) and Sensory Profile (SP, Dunn, 1999)

To avoid coding the same behaviour twice and conflating the sensory and RMBs measures, RMBs were always coded on the RMB measure, regardless of whether they had a sensory component. However, two concurrent but distinct behaviours, one being sensory and the other being RMB, could both be coded (e.g. visually fixating on the bubble tube (sensory), whilst also tapping leg (RMB)). Additionally, as the iPad and the activatable touch, sound and light board buttons were only available in the control condition, sensory and RMBs could not be coded when they directly related to these equipment (e.g. repetitively tapping iPad).

3.2.2.7 iPad holding and sensory changes

In the control condition, participants could change the colour of the touch, sound and light board, fibre optics, LED room lights and bubble tube, as well as activating and deactivating the mirror ball. An iPad was used to make these changes for all equipment apart from the touch, sound and light board, which was activated directly. The number of sensory changes (i.e. colour changes or activation) that the participant produced was tallied. Tallying the number of sensory changes in the MSE was preferred to tallying the number of iPad presses as the iPad was not always visible (e.g. occluded by participant’s body). In addition, as the iPad was only available in the control condition, the duration it was held for was also coded in order to investigate if holding the iPad limited the amount or duration of physical behaviours (e.g. RMBs).

3.2.2.8 General coding principles and the coding software

Codes that measured frequency and duration were inputted into ELAN (ELAN, 2018), a freely available coding software. In ELAN the behavioural categories (e.g. social behaviour) were called ‘tiers’, and these tiers contained a ‘controlled vocabulary’, which was a list of the individual behaviours that could be coded for each tier (e.g. showing). Video footage was imported into ELAN and the three cameras were temporally synced. To code a behaviour, the video streams were paused, and on the relevant tier a cursor was dragged from the start to the end of the behaviour. Then, the name of the behaviour being coded could be selected from the controlled vocabulary list on that tier. Excel spreadsheets were used for the global rating codes.

The MSE sessions were captured on three cameras at different positions in the MSE (described in Chapter 4). For coding, only one of the three camera feeds were focussed on at a time to ensure that behaviours were not double coded, and so that the duration of the behaviour was coded accurately. An additional study control was coding experimenter speech to see if it differed between conditions, as more speech in one condition would affect interpretations of findings.

3.2.2.9 Coding scheme reliability

All videos were coded by a primary coder (KU), but to ensure reliability, a second coder (LS) coded 25% of the sample (*n*=10 participants, including all conditions: control, no control and free play), and inter-rater reliability (IRR) was calculated using Intraclass Correlations (ICC). LS was trained using six different participants before reliability coding commenced. Participants were selected using a random number generator (www.random.org).

Training on each coding scheme was necessary to highlight coding biases (e.g. one coder consistently not coding ‘trembling’), and discrepancies in behavioural definitions, as well as enabling the coders to familiarise themselves with the intricacies of the coding scheme. During training, both coders would independently code the same participant on one coding scheme and then discuss any issues. In some cases, codes had to be refined or combined if they were confusingly worded, lacking in sufficient detail, or could not be reliably coded. For example, in the anxiety scheme, ‘whine’ and ‘whimper’ were originally separate codes. However, during training the coders could not reliably distinguish between them so they were combined. Very few changes were made during training and they were all minor. After changes were made to a scheme, the training process would be repeated on a different participant to check that the modifications were sufficient. Once both coders agreed that the coding schemes were well defined and they felt familiar with the schemes, they independently coded all ten participant videos across all conditions, on all coding schemes. According to Cicchetti's (1994) widely-cited cut-offs (<.40 poor, .41-.59 moderate, .60-.74 good, >.75 excellent), excellent ICC was achieved for all coding schemes (Table 3.6), apart from sensory duration which had moderate but acceptable reliability (Cicchetti, 1994; Koo & Li, 2016).

Table 3.6. Inter-rater reliability (IRR) intraclass correlations (ICC) for the coding measures

Measure	**ICC**	**Sig.**
Anxiety	.84	<.001
Global anxiety	.00*	-
Enjoyment	.95	<.001
Global enjoyment	.98	<.001
RMB frequency	.90	<.001
RMB duration	.96	<.001
Sensory frequency	.89	<.001
Sensory duration	.55	.05
Social	.98	<.001
Gesture	.91	.001
Mimicry	.97	<.001
Attention	.94	<.001
Rapport	.86	<.001
Speech frequency		
Experimenter speech	.99	<.001
Non-autistic speech	.99	<.001
Autistic speech	.89	.001
Vocalisations	.98	<.001
Speech duration		
Experimenter speech	.99	<.001
Non-autistic speech	.99	<.001
Autistic speech	.97	<.001
Vocalisations	.99	<.001
iPad holding	.98	<.001
Sensory changes	.99	<.001

*Zero variance implying ICC could not be calculated, however, percentage calculations demonstrated 100% agreement.

The MSE and coding schemes described in this Chapter were used in the studies presented in Chapter 4 and 5.

Chapter 4: The effect of being in control of the Multi-Sensory Environment on behaviour, mood and physiological arousal of autistic children

4.1 Introduction

Chapter 1 reviewed studies investigating the effects of MSEs with varied findings, but low levels of scientific rigour (e.g. Chan et al., 2010; Hogg, Cavet, Lambe, & Smeddle, 2001; Lotan & Gold, 2009) affect the ability to draw firm conclusions about their effect. Particularly, MSEs are widely used with autistic individuals but only five studies have investigated the effect of MSE use on autistic individuals with these studies being largely descriptive due to small sample sizes (Fava & Strauss, 2010; Kaplan et al. 2006; McKee et al. 2007; Mey et al. 2015), or limited by methodological issues (Novakovic et al. 2019).

Within this field of study, there has been limited discussion of, and justification for, the outcomes that are investigated. Therefore, in Chapter 2, a range of relevant outcome measures were identified through interviews with educational practitioners who regularly use MSEs with autistic children. These included social interaction and communication, RMBs, focus and attention, enjoyment and anxiety.

Interpreting previous research into MSE use is also limited by inadequate description of how the MSE sessions were structured. There is very limited insight into the ways of use or specific elements of the MSE that facilitate change, both positive and negative. However, two studies investigated the effect of caregiver attention within an MSE on the behaviour of children with ID, with one study investigating the effect of high versus low practitioner attention (Hill et al., 2012), and another investigating attention from a family member compared to having no adult present (Glenn et al., 1996). These studies had some contrasting findings with Hill et al. (2012) reporting no difference in stereotyped behaviours from high caregiver attention, but Glenn et al. (1996) reporting decreased stereotyped behaviours when the family member was present. Presence of a family member also led to an increase positive mood, enjoyment and pro-social behaviour (Glenn et al. 1996), and high practitioner attention was found to promote better engagment (Hill et al. 2012). Fava and Strauss (2010) measured the effects of free-use versus structured MSE sessions on stereotyped behaviour and reported a reduction in the free-use condition in both autistic and ID adult participants. Therefore, evidence suggests that the distinct way in which the MSE is used can have impact on behaviour. To date, no study has investigated the effect of different modes of MSE use on autistic children.

The sequential mixed methods study (Chapter 2) investigated the opinions of educational practitioners about methods of MSE use that enabled positive outcomes with autistic children. Practitioners suggested the MSE being motivational, enabling relationship building, providing sensory stimulation, and allowing the child to be in control of the sensory equipment were all properties that facilitated benefits. Due to time constraints, only one of these factors could be investigated in the thesis. Control of the equipment was amendable to manipulation, operationalizable and was supported by a range of theories. However, there are also theories specifically relevant to autism that may explain the mechanism of action of control.

4.1.1 Effect of control on meeting sensory needs

As discussed in Chapter 1, autistic individuals have heterogeneous, unusual sensory profiles characterised by the presence of hyper-, hypo-sensitivities and unusual sensory interests (APA, 2013; Baranek, David, Poe, Stone, & Watson, 2006). Sensory issues have been associated with the presence of sensory behaviours (e.g. Lane, Young, Baker, & Angley, 2010), RMBs (Joosten & Bundy, 2010; Leekam, Prior, & Uljarevic, 2011), anxiety (Ben-Sasson et al., 2008; Joosten & Bundy, 2010; Uljarević, Lane, Kelly, & Leekam, 2016; Wigham, Rodgers, South, McConachie, & Freeston, 2015), attention (Ashburner, Ziviani, & Rodger, 2008), and difficulties with social communication (Baum, Stevenson, & Wallace, 2015; Hilton, Graver, & LaVesser, 2007). A prominent theory attempting to explain MSE functioning suggests that MSEs are beneficial because they provide sensory stimulation (Baillon et al. 2002; Chan, Fung, Tong, & Thompson, 2005; Chan et al., 2010; Eijgendaal et al., 2010; Hutchinson & Hagger, 1994; Mey, Cheng, & Ching, 2015; Moore, Harris, & Stephens, 1994), and having control of the MSE may enable the child to meet their specific sensory needs and thereby, modulate these aforementioned sensory-associated behaviours (e.g. reducing anxiety).

Sensory behaviours, and to some extent RMBs, can occur in direct response to sensory experiences and serve as a way of meeting sensory needs (e.g. Ben-Sasson et al., 2008; Leekam et al., 2011). Both sensory behaviours and RMBs are also suggested to have a regulatory function whereby performing the behaviour enables arousal to be increased during states of hypo-arousal and decreased during hyper-arousal (e.g. Ben-Sasson et al., 2008; Leekam et al., 2011). Therefore, the capacity of MSEs to tailor the sensory environment to meet sensory and arousal needs could reduce the need for sensory behaviours and RMBs.

Hilton, Graver and LaVesser (2007) found that sensation avoiding was strongly associated with social impairment in autism, suggesting that social interactions are avoided because they involve potentially overwhelming sensory input. They also found sensory seeking behaviours positively correlated with social impairment, and subsequently suggested that distraction from, or preoccupation in, sensory seeking behaviours could limit social interaction. These findings could suggest that when the child can control sensory input and optimise the sensory environment, it may facilitate social communication and interaction.

4.1.2 Effect of control on predictability and intolerance of uncertainty

Previous MSE theory has suggested that when the MSE can be controlled, it becomes more predictable and therefore has a positive effect on behaviour (Eijgendaal et al., 2010; Fowler, 2008; Hirstwood & Smith, 1996), although this theory is currently untested. As discussed in Chapter 1, uncontrollable sensory stimuli (e.g. room lights in a shared space, unexpected physical contact, loud music) are perceived as aversive, distressing and unpleasant by autistic people (Ashburner et al., 2013; Dickie et al., 2009; Robertson & Simmons, 2015), while controllable sensory stimuli are experienced positively (Robertson & Simmons, 2015). Of particular relevance, one of Robertson and Simmons' (2015) participants described feeling relief at being able to control the sensory environment in a 'chill-out' room. In their questionnaire study, Fujino et al. (2019) also found that their autistic sample had a greater preference for environmental predictability compared to a non-autistic group.

This preference for predictability can be explained by a well-validated finding that autistic individuals experience high levels of IoU (Boulter et al., 2014; Neil et al., 2016). As discussed in Chapter 2, autistic individuals want to limit ambiguity and thereby prefer predictability in their surroundings. Based on models by Boulter et al. (2014) and South and Rodgers (2017) (see Discussion, Chapter 2), it can be speculated that when sensory input is controlled in an MSE, the stimulation becomes predictable and IoU may be ameliorated, which could lead to reductions in anxiety and RMBs. It is also conceivable that improved control could lead to improvements in other behaviours (e.g. enjoyment), either directly or as a consequence of a reduction in RMBs and anxiety. This suggestion is reinforced by the practitioner's beliefs presented in Chapter 2, as they stated that a reduction in anxiety within the MSE can lead to improvements in many different outcomes, including the ones selected for the present study.

Also discussed in Chapter 2, Bayesian predictive coding theory (e.g. Pellicano & Burr, 2012) may also provide insight into the consequences of having control. It is suggested that the autistic child being in control of their sensory environment may reduce prediction error and neural load because the changes are predictable. As such, the child may be less overwhelmed, and other behaviour changes such as reduced RRBs may be possible.

4.1.3 The current study

No study to date has empirically investigated the effect that having control has on the behaviour, mood and arousal of autistic children. Autistic children aged 4 to 12 years will use the MSE twice with an experimenter. In one condition they will have control over the MSE equipment, and in the other condition, they will not have control and the MSE equipment will change without their input. Within each condition the experimenter will guide them to use one piece of equipment at a time for three minutes in a randomised order. The sessions will be video recorded and later be coded for the following behaviours (based on findings from Chapter 2): RMBs, sensory behaviours, anxiety, enjoyment, attention, and social communication (including, speech, rapport, social behaviours, gestures and mimicry). Additionally, physiological arousal measurement will provide an objective measure of the effect of the MSE on arousal. A secondary aim was to use standardised parent-report questionnaires to investigate whether the behaviours within the MSE associated with similar behaviours seen in 'real life'. It is hypothesised that having control of the MSE equipment will have a positive effect on behaviours compared to not having control. Specifically, there will be an increase in enjoyment, social communication, and attention, and a decrease in RMBs, sensory behaviours and anxiety.

4.2 Method

4.2.1 Participants

Forty-four autistic children took part in the study, but three were removed from the sample due to data loss (*n*=1 one camera angle was missing in one condition, and *n*=2 participants did not complete both MSE sessions). Therefore, forty-one autistic children (8 female) aged 4-12 years (*M*=8 years, *SD*=2.05 years) were included in the final sample. Recruitment was through the Wales Autism Research Centre's Facebook page and recruitment register. The inclusion criteria was aged 4 -11 years (note one participant turned 12 before taking part), have a diagnosis of autism, not have a diagnosis of a co-occurring developmental disorder (e.g. ADHD), be able to work one-to-one with the a previously unknown adult in the MSE, and not have any significant hearing, visual or mobility issues.

ADOS-2 (Lord et al., 2012) comparison scores ranged from 5-10 (*M*=7.8, *SD*=1.45), indicating all participants showed levels of autistic symptoms commensurate with their diagnosis. Twenty participants scored within the 'high' autism symptom category (8-10), and twenty presented with 'moderate' autism symptoms (5-7). Video data was lost for the ADOS-2 of one participant. However, this participants' Social Communication Questionnaire (SCQ; Berument, Rutter, Lord, Pickles, & Bailey, 1999; Rutter, Bailey, & Lord, 2003) score was 24, above the autism cut-off score of 15. The majority of the sample (71%) attended mainstream schools, but 52% of these participants either had one-to-one support or were educated at a specific autism base within the school. The remaining 29% attended special-needs schools.

The parents completed a short questionnaire about previous MSE use. Of the 41 participants, 54% were reported to have used an MSE before, with 15% reportedly using an MSE daily, 15%

weekly, and 24% infrequently (i.e. several times a year, or only a few times in total). Whereas, 46% of the participants had never used an MSE. The majority (55%) of participants who had used an MSE before had used it at school.

For participants who were aged six and over and were verbal (*n*=19), ability was measured using the Wechsler Abbreviated Scale of Intelligence (WASI-II; Wechsler, 2011). WASI-II is a test providing a standardised measure of intelligence for individuals aged six to 90 years. It contained four sub-tests including two verbal and two non-verbal sub-tests. The verbal sub-tests include: Vocabulary (i.e. providing definitions for presented words; e.g. "shirt") and Similarities (i.e. describing the factor of similarity between two words or concepts; e.g. "blue and green"). The non-verbal sub-tests include: Block design (i.e. copying the pattern displayed in a 2D picture using coloured blocks), and Matrix reasoning (i.e. identifying the missing drawing that would complete a sequence of related simple and abstract drawings). Where the participant was over the age of six but was not verbal (*n*=9), the two non-verbal sub-scales of the WASI-II (block design and matrix reasoning) were administered providing non-verbal intelligence quotients (NVIQ).

For those under six years (*n*=13), the Wechsler Preschool and Primary Scale of Intelligence (WPPSI-IV; Wechsler, 2012) was used. WPPSI-IV is a standardised test of intelligence for those aged 2 years 6 months – 7 years 7 months. In this study sub-tests to calculate NVIQ were administered. These included Block design, Matrix reasoning (both similar to WASI-II), Bug search (i.e. identifying which insect in a series matches the target insect) and Picture memory (i.e. identifying a picture from a list that was presented previously).

For some participants, fatigue or behavioural issues prevented administration of the ability measure, either fully or in part (*n*=11). In these instances, a session was arranged at the participant's school to complete administration. Six participants were not able to access ability assessments at either location, therefore ability scores are available for 35 participants (WASI-II=19; WPPSI-IV=16). Verbal sub-scale scores (*n*=19) ranged from 59-126 (*M*=94.32, *SD*=19.74), NVIQ (*n*=35) scores ranged from 46-142 (*M*=90.43, *SD*=24.23), and full-scale IQ (FSIQ; *n*=19) ranged from 69-128 (*M*=96.95, *SD*=15.75). Overall, there were nine participants who scored below 70 on NVIQ, which is indicative of ID. Individual participant information is included in Table 4.1. Ethical approval for this study was granted by the School of Psychology Ethics Committee, Cardiff University.

4.2.2 Design and materials

A within-subjects design was used where each participant took part in both types of MSE use, control and no control. In the control condition they changed equipment themselves using an iPad or when at the touch, sound and light board, they used the equipment itself (i.e. buttons on the board). In the no control condition, each respective piece of equipment, apart from the mirror ball, changed colour every three seconds without their input. The mirror ball was activated and rotated for the three minutes. The order that the participants engaged in each condition was counterbalanced.

Table 4.1. Participant demographics including age, gender, ability, Autism Diagnostic Observation Schedule-2 (ADOS-2) module and comparison score, previous Multi-Sensory Environment (MSE) use and type of schooling.

ID	Age (years)	Gender	FSIQ[a]	VIQ[b]	PIQ/ NVIQ[c]	ADOS-2 module	ADOS-2 comparison score	Previous MSE use	Schooling
1	10	M	110	108	111	3	8	No	Mainstream
2	7	F	-	-	58*	1	7	Daily	Special needs
3	7	M	-	-	64*	1	6	No	Mainstream[±]
4	7	M	-	-	46*	1	7	Infrequently	Mainstream[±]
5	5	M	**			1	9	Weekly	Special needs
6	6	M	74	62	92	2	7	Infrequently	Mainstream[±]
7	4	M	**			1	10	No	Nursery
8	8	M	-	-	110	1	6	Daily	Special needs
9	7	F	128	120	129	3	9	Infrequently	Mainstream
10	7	M	**			1	8	Weekly	Special needs
11	4	M	-	-	77*	1	9	Infrequently	Mainstream[±]
12	11	M	102	91	112	3	9	No	Mainstream
13	6	F	-	-	56*	1	7	Weekly	Special needs
14	9	M	96	103	90	3	6	No	Mainstream
15	10	M	69	79	62	3	10	Infrequently	Mainstream[±]
16	9	F	-	-	83	2	9	Infrequently	Special needs
17	10	M	111	114	105	3	5	No	Mainstream
18	6	M	-	-	55*	1	8	No	Mainstream[±]
19	9	M	**			1	7	Weekly	Special needs
20	5	M	-	-	93*	3	8	No	Mainstream
21	7	M	120	126	107	3	7	No	Mainstream
22	8	M	-	-	96	1	6	Weekly	Mainstream[±]
23	6	M	-	-	59*	1	7	No	Mainstream[±]
24	12	F	100	97	103	3	10	No	Mainstream
25	10	F	79	83	79	3	9	No	Mainstream[±]
26	8	M	-	-	63	1	7	No	Special needs
27	10	M	108	105	108	3	6	No	Mainstream
28	8	M	-	-	130	1	5	Daily	Mainstream[±]
29	8	M	-	-	60	1	7	Infrequently	Mainstream[±]
30	8	M	75	67	89	3	10	No	Mainstream
31	6	M	-	-	142	2	7	No	Mainstream[±]
32	7	F	95	113	79	3	8	Infrequently	Mainstream
33	6	M	89	75	105	3	9	No	Mainstream
34	7	M	86	59	117	3	10	Weekly	Mainstream[±]
35	10	M	105	102	107	3	9	No	Mainstream
36	7	M	93	84	105	3	9	Infrequently	Mainstream[±]
37	6	F	**			1	7	Daily	Special needs
38	10	M	-	-	74	1	10	Daily	Special needs
39	10	M	105	111	97	3	7	No	Mainstream
40	4	M	**			-	-	Daily	Special needs
41	11	M	97	93	102	3	7	Infrequently	Mainstream[±]

[a] FSIQ: Full Scale Intelligence Quotient score calculated from the four scales of the Wechsler Abbreviated Scale of Intelligence (WASI-II; Wechsler, 2011); [b]VIQ: Verbal Intelligence Quotient score calculated from 2 verbal subscales of the WASI-II; [c]PIQ: Performance Intelligence Quotient calculated from the 2 performance subscales of the WASI-II. Scores marked with * were calculated as Non-Verbal Intelligence Quotient (NVIQ) scores from the Wechsler Preschool and Primary Scale of Intelligence (WPPSI-IV; Wechsler, 2012); - Score could not be calculated due to lack of verbal ability; ** Not administered; ± Child receives either 1:1 support or attends an autism base within a mainstream school.

The order that each participant used the equipment was randomised using a Latin square, with each participant using the equipment in the same order in both conditions. The order of the ADOS-2 and ability assessment was randomised for each participant (using www.random.org).

The behavioural outcome variables were coded from video recordings of the sessions and included social behaviours (including, gestures and mimicry), speech, rapport, attention, sensory behaviour, RMBs, anxiety and enjoyment. Both frequency and duration (s) were coded for speech, sensory and RMBs, whereas only frequency was coded for social behaviours, anxiety and enjoyment. Rapport and attention were coded using global scores. As control measures, duration of experimenter speech (s) as well as duration of iPad holding (s) and number of child-driven sensory changes in the control condition were measured. Full definitions, descriptions and individual codes for each coding scheme can be found in Chapter 3.

To measure HRV an Actiwave Cardio chest monitor (CamNTech, Cambridge, UK) measuring 32mm in diameter, with a thickness of 10mm, and weighing 10.3g was used. It can be worn comfortably and unobtrusively on the centre of the chest by both children and adults, attached using typical echocardiogram (ECG) electrodes (50mm). The Actiwave recorded at 512Hz (stored at a resolution of nine bits), with acceleration rate (i.e. movement) sampled at 32Hz (stored at a resolution of eight bits).

4.2.2.1 Parent questionnaires

Parents completed eight questionnaires on their child’s autistic symptoms and everyday behaviour.

2.4.2.1.1 Anxiety

Spence’s Children's Anxiety Scale-Parent (SCAS-P; Spence, 1999) is a 38-item measure of the frequency of anxiety behaviours presented by a child on a four-point Likert scale (0-3) from “Never” to “Always”. Scores range from 0-114 with a higher score indicating higher anxiety symptoms. SCAS has acceptable validity and satisfactory to excellent reliability (Nauta et al., 2004). Internal consistency calculated from the present sample was excellent (α=.93).

The Anxiety Scale for Children-ASD (ASC-ASD; Rodgers et al., 2016) was included as an autism-specific measure of anxiety. The parent version of the ASC-ASD is a 24-item questionnaire where a parent rates the occurrence of anxiety behaviours shown by their autistic child on a four-point Likert scale (0-3) from “Never” to “Always”. Scores range from 0-72, with a higher score indicating higher anxiety symptoms. The ASC-ASD parent version has good to excellent reliability and validity (Rodgers et al., 2016). Internal consistency calculated from the present sample was excellent (α=.94). Responses from the two measures were strongly positively correlated (r=.85,p<.001).

Intolerance of Uncertainty

The Intolerance of Uncertainty, 12-item, parent report measure used here (IOU-12P; Boulter, Freeston, South, & Rodgers, 2014) was adapted from a 12-item self-report version of this measure (Carleton, Norton, & Asmundson, 2007). The IOU-12P requires the parent to state how characteristic a set of behaviours associated with IoU are for their child on a five-point Likert scale (1-5), from “Not at all characteristic of my child” to “Entirely characteristic of my child”. Scores range from 12-60, with a higher score indicating higher IoU. Although the IOU-12P has not yet been validated, the 12-item self-report version that it is derived from has good validity and reliability (Carleton et al., 2007). Internal consistency calculated from the present sample was excellent (α=.90).

2.4.2.1.2 Sensory behaviours

The Sensory Profile (SP; Dunn, 1999) is an 125-item parent questionnaire to measure the child’s sensory response to a range of sensory experiences. Responses are on a five-point Likert scale to indicate the frequency with which they have seen each sensory response by their child from “Always” (1) to “Never” (5). Scores were calculated in four quadrants: low registration (score range = 15-75), sensation seeking (26-130), sensation sensitivity (20-100), and sensation avoidance (29-145), with lower scores indicating higher levels of sensory symptoms. Reliability for the different sections ranged from acceptable to excellent, with generally good validity (Dunn, 1999). Internal consistency calculated from the present sample was excellent (α=.96).

The Sensory Experiences Questionnaire (SEQ, version 2.1 short form including fascinations addendum; Baranek, 1999) contains 37-items. For this measure a parent is asked to rate their child’s response to a sensory experience on a five-point Likert scale from “Almost never” (1) to “Almost always” (5). Scores range from 32-160, with a higher score indicating more sensory disturbance. Both reliability and validity are good (Baranek, 1999a; Baranek & Costello, 2003). Internal consistency calculated from the present sample was acceptable (α=.78).

2.4.2.1.3 Restricted and repetitive behaviours

The Repetitive Behaviour Questionnaire-2 (RBQ-2; Leekam et al., 2007) consists of 20 items that record three different types of response: frequency (questions 1-6), severity (questions 7-19) and the type of activity preferred (question 20). For each of the frequency questions the parent rates the frequency with which their child engages in the RRBs on a four-point Likert scale (1-4) from “Never or rarely” to “30 or more times daily (or twice an hour)”. For the severity items, the parent rates behaviours on a three-point Likert scale (1-3) from “Never or rarely” to “Marked or notable”. The parent responds to the final question regarding child choice of activity on a three-point Likert scale (0-3) from “A range of different and flexible self-chosen activities” to “Almost always chooses from a restricted range of repetitive activities”. The total score ranges from 20-60, with a higher score indicating greater frequency and severity of RRBs. Two subscale scores were also calculated (Lidstone et al.,2014), ‘Motor/Sensory behaviours’ (score range=8-24) and ‘Insistence on sameness’ (9-27). The RBQ-2 has have good reliability (Leekam et al., 2007; Lidstone et al., 2014) and validity (Leekam et al., 2007). Internal consistency calculated from the present sample was good (α=.82).

2.4.2.1.4 Attention deficit and hyperactivity disorder behaviours

The ADHD measure was created by Thapar, Harrington, Ross, and McGufffin (2000) and consisted of a modified version of the DuPaul ADHD rating scale (DuPaul, 1981) combined with items from Conners’ Abbreviated Parent Questionnaire (CAPQ; Conners, 1973), ICD-10 (World Health Organisation, 1992) and DSM-IV (American Psychiatric Association, 2010). This 26 item measure was selected over the DuPaul (DuPaul, 1981) as it provides a more comprehensive and diagnostically relevant measure of ADHD. The parent states how much the behaviours are shown by their child on a four-point Likert scale (0-3) from “Not at all” to “Very much”. Scores ranged from 0-78, with higher scores indicating more ADHD symptoms. No published reliability and validity data were available, but the internal consistency calculated from the present sample was excellent (α=.90).

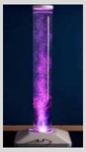
2.4.2.1.5 Autistic behaviours

The Social Communication Questionnaire (SCQ; Berument, Rutter, Lord, Pickles, & Bailey, 1999; Rutter, Bailey, & Lord, 2003) consists of 40 items. Parents respond whether the behaviour is present for their child using “Yes” (1) or “No” (0). Scores range from 0-39, with a higher score indicating more autistic symptoms, and a score of greater than 15 indicating those who are likely to be autistic. It has excellent reliability and good validity (Berument et al., 1999). Internal consistency calculated from the present sample was good (α=.80).

4.2.2.2 MSE equipment

The MSE sensory equipment is described in Chapter 3, but not all purchased equipment was relevant for the current study. The equipment included in the current study was the bubble tube, mirror ball, LED room lights, fibre optics and touch, sound and light board (Table 4.2). Three handheld portable cameras (two Sony HDR-CX280E, and one Panasonic HC-V720) were used to record the sessions and were positioned at three vantage points within the MSE. The camera position enabled the whole space to be recorded (see diagram in Appendix E). The cameras were mounted just below ceiling height; they were unobtrusive and not noticed by the participants. The iPad used was an iPad Air 2 which ran S4 software (Mike Ayres Design Ltd., 2012) to control the equipment though WiFi connectivity.

Table 4.2. Each piece of equipment within the Multi-Sensory Environment (MSE) and how it can be engaged with and change in each condition. Note: the eight colours include red, orange, yellow, light green, dark green, light blue, dark blue and purple/pink.

Item	Description	Control condition	No control condition
Bubble tube 	The tube is filled with water and bubbles travel up the tube continuously. The water can be changed to be one of eight colours	One of eight colours can be selected at any given point within the 3 minutes	One of eight alternating colours are presented every 3 seconds
Coloured LED room lights 	Lights which change the whole colour of the room to be one of eight colours	One of eight colours can be selected at any given point within the 3 minutes	One of eight alternating colours are presented every 3 seconds
Fibre optics 	Fibre optic cabling is attached to a light box. The colour of the cabling can be changed to be one of eight colours	One of eight colours can be selected at any given point within the 3 minutes	One of eight alternating colours are presented every 3 seconds
Touch, sound and light board 	The board contains eight buttons. When touched it produces a coloured light and a sound	Eight buttons can be pressed on the equipment lighting up one of eight colours and playing a piano note. Buttons can be pressed concurrently	All eight colours are activated throughout. Each colour changes position on the board every 3 seconds. No piano notes are played
Mirror ball 	Pin-spot light shines on the spinning mirrored surface of the ball and subsequently small lights are projected onto the walls	Activate and de-activate the spotlight that shines onto the continually rotating mirror ball, turning the mirror ball lights on and off	Remains activated and lights from the mirror ball spin around the room throughout

4.2.3 Procedure

The procedure of this study is outlined in Table 4.3 and then described in further detail below.

Table 4.3. Procedure of Multi-Sensory Environment (MSE) study

Order	Activity
1st	**Heart Rate Variability baseline session**: Free play with toys in a playroom
2nd	**First MSE condition**: Control or no control (counterbalanced)
3rd	Break
4th	**Ability measure or Autism Diagnostic Observation Schedule (ADOS-2)** (alternated order between participants)
5th	Break (if required)
6th	**Ability measure or ADOS-2** (alternated order between participants)
7th	Break (if required)
8th	**Second MSE condition**: Control or no control (counterbalanced)
9th	**Free play MSE session** (Chapter 5)

First, a baseline measure for the HRV data was collected. The participant played independently with a range of age-appropriate toys (including a puzzle, a game, Lego or Duplo) for five minutes in a regular testing room that had been kitted out as a playroom. None of the toys had explicit sensory qualities (i.e. they did not light-up or play music). During this time, the experimenter (KU) sat at a distance from the child, not speaking unless spoken to, to limit social pressure on the child.

For both MSE conditions, using a wall-mounted visual aid, the participant was explained the order that they would use the equipment. The participant was led to each piece of equipment at a time and spent three minutes at each piece.

In the control condition, the relevant piece of equipment was turned on and the iPad (Figure 4.1) was handed to the child with the instruction, “You can play”. If the child did not press a button on the iPad, one press was demonstrated by the experimenter with the instruction, “Look, like this”. The majority of participants used the iPad after the first instruction and all other participants responded after the second instruction. The same protocol and instructions were used at the touch, sound and light board (i.e. “You can play” and “Look, like this”). In the no control condition, the instruction “You can play” was provided without the iPad. Table 4.2 outlines each piece of equipment and how it can be engaged with and change in each condition. The relevant equipment was turned off after it had been used.

Figure 4.1. Photograph of the iPad 2 running the S4 app displaying of all eight buttons that can be used to change the colours on certain pieces of equipment (see Table 4.2).

For both conditions, the experimenter spoke four novel utterances during each three-minutes of equipment use. These four utterances were used to standardise the amount the experimenter spoke, as well as provide explicit opportunities for the participant to engage. Two of the four utterances were factual statements about the piece of equipment, and two were statements that were metaphors (described as "imaginary"). Two of the four utterances were also accompanied by an action (Table 4.4). In addition to these four utterances, the experimenter could also speak if the participant asked a question that required a response, but the response had to be minimal. If the participant moved away from the equipment during the three minutes and had to be bought back, specific phrases were used as appropriate: "Not finished yet", "Play over here" and "You can play".

Table 4.4. Examples of the four utterances presented at the fibre optics

Utterance type	**Example at the fibre optics**
Imaginary with action	Utterance: "Look, it's like a jelly fish" Action: Picking up fibre optics and flicking them like tentacles
Imaginary without action	Utterance: "Look, it's like wiggly worms"
Factual with action	Utterance: "Look, [pause]" Action: Tapping three times on the fibre optics
Factual without action	Utterance: "Look, that red is bright"

Note: The action was concurrent with the utterance

In between the MSE conditions the ADOS-2 and ability assessments (WASI-II or WPPSI-IV) were conducted. After the second MSE condition, the participant engaged in free play for five minutes, this is discussed in Chapter 5. Between each activity the participant had a break with their parent, if necessary. At the end of the testing session, each participant received a certificate and a pencil, rubber and stickers for taking part. Testing sessions lasted from two to four hours.

Whilst the participant was taking part in the testing sessions, their parent completed eight standardised questionnaires about participant's everyday behaviours. These questionnaires were presented on a laptop using Qualtrics software (Qualtrics, Provo, UT) and the order of the questionnaires was randomised.

4.2.4 Data preparation and analysis

4.2.4.1 Behavioural coding

Each participant's video recording was trimmed (for ease of administration cameras recorded the full testing session, not just the experimental sessions) and converted from a .MTS file into a .MP4 file using Shotcut open-source video editing software (Shotcut, 2011). Each of the three camera angles and the template for the coding scheme were then loaded into ELAN video coding software (ELAN, 2018). As a study control, to avoid coding different durations of sessions due to variable transition times, only the three-minutes at each piece of equipment was to be coded. Each condition (i.e. control, no control and free play) for each participant was watched seven times in order to code all the measures (Table 4.5). The order that each condition was coded for each participant for each measure was randomised using www.random.org.

Table 4.5. The fixed order of coding for the control and no control conditions. Each row represents a separate viewing of the video.

Coding order	Coding conducted
1st	Anxiety & enjoyment
2nd	Speech (including experimenter speech)
3rd	Social behaviours, gestures, mimicry and rapport
4th	Sensory behaviours & RMBs
5th	Attention
6th	MSE changes from iPad or Touch, sound and light board presses
7th	iPad holding

Raw data were exported into SPSS (IBM corportation, version 25, 2017) and the total frequency of social, gesture, mimicry, anxiety, enjoyment, speech, RMBs and sensory behaviours scores were calculated by summing individual behaviour codes from each scheme. The total durations of speech, RMBs and sensory behaviours were also calculated. For sensory behaviours, frequency and duration sub-codes of 'seeking' and 'defensive' behaviours were created by summing respective individual modality codes. To ensure that any behavioural or speech difference between conditions were not due to more experimenter speech in one condition, frequency and duration of experimenter speech was analysed. There was no significant difference in the frequency ($M_{difference}$=1.78, *SD*=18.73; $t(40)$=.61,p=.55,d_z=.10) or duration ($M_{difference}$=-.03, *SD*=21.63; $t(40)$=-.01,p=.99,d_z=.001) of experimenter speech between the two conditions.

4.2.4.2 Arousal

Physiological arousal was measured using HRV, a metric quantifying the variability between interbeat intervals (IBIs; i.e. the variability in the amount of time between successive heart period/beats). High HRV is an indicator of low physiological arousal and indicates relaxation. A measure of movement was also taken using accelerometery data from the HRV monitor.

There are multiple available measures of HRV that vary in their appropriateness based on study design and the heart monitoring equipment used (for reviews see; Berntson, Lozano, & Chen, 2005; Task Force for the European Society of Cardiology, 1996). Considering that the present study design aimed to measure heart rate variability over short periods, a measure was required that would be sensitive to high-frequency changes in heart period over this time. Therefore, the time-domain measure root mean square successive difference (RMSSD) was selected as it met this criterion (for reviews of methods see; Berntson et al 2005; Task Force for the European Society of Cardiology, 1996). RMSSD was also deemed appropriate as it has been found to be less affected by respiratory rate (e.g. Hill & Siebenbrock, 2009) than other measures.

Participants' raw ECG files were uploaded into the Actiheart software (version 5.0.5, CamNTech). The accelerometery data is converted into 'activity counts' and is outputted alongside the ECG trace. RMSSD and activity scores were calculated for the five-minute baseline and three consecutive five-minute epochs from the MSE sessions (control and no control condition and free play session). Because of issues with data quality (see below), the three, five-minute epochs were averaged to give one RMSSD score per MSE session.

Prior to RMSSD calculation, ECG signals need to be checked for the quality of output as quality can be affected by noise in the signal. Noise occurs predominantly from the monitor picking up electrical signals from the environment, or from issues with signal detection by the monitor. The Actiheart software runs specific algorithms that identify noise and attempt to automatically discard artefacts from the IBI sequence. Then, within each selected epoch, another algorithm estimates the proportion of IBIs that are within +/-25% of the average heart rate, producing a 'quality score' between 0 and 1 to reflect how many IBIs were outside of the average (i.e. the more IBIs within +/-25% range, the higher the score). CamNTech suggest that scores below .6 indicate poor quality data and therefore, epochs with scores <.6 were removed. The activity score, derived from the accelerometery data, is also calculated for each epoch.

4.2.4.3 Analysis plan

Checking procedures were used to inspect the difference scores used in analysis for outliers and normality of distribution. These procedures included visual inspection of histograms (i.e. degree of conformation to bell-curve form), Shapiro-Wilks test (i.e. significant result indicating non-normality), inspection of box-plots (i.e. to identify any outliers +/-2SD away from the mean), and obtaining z-scores using skewness and kurtosis (i.e. dividing the skewness and kurtosis respectively by their standard errors, if the resulting number is +/-1.96, the data is suggested to be non-normal, Kim, 2013). Transformations were attempted for non-normal variables, and transformation type (e.g. square root, logarithmic) depended on the severity of the skewness of the data. Where the transformations did not improve the distribution, or the data contained numerous legitimate outliers (common in data on autistic individuals due to wide heterogeneity), non-parametric tests were used, and medians reported. For normally distributed data, paired-samples t-tests were used.

To test the primary hypothesis that the control condition has a positive effect on behaviour compared to the no control condition, outcome variables were compared between the control and no control conditions to test for differences. Where significant, analyses were conducted on the individual codes that constituted each overall outcome variable. Analyses of the activity and HRV data also included comparisons with the baseline condition. Additional analyses were conducted based on a priori hypotheses, or where further analyses were needed to interpret a significant effect. For the secondary investigation of the parent-report of behaviours, questionnaire scores were presented descriptively and correlated with relevant outcome measures.

For paired-samples and one-samples t-tests, effect size will be calculated using Cohen's $d_{z,}$ where $d_z=\frac{t}{\sqrt{n}}$ (Cohen, 1988; Lakens, 2013). According to Cohen (1988), a small effect is d_z = .02, medium = .05 and large = .08. For Wilcoxon's Signed Ranks comparisons, r will be calculated to demonstrate effect size, as recommended in Fritz, Morris and Richler (2012), where $r=\frac{z}{\sqrt{n}}$. According to Cohen (1988) a small effect is r = 0.1, medium = .03, and large = .05.

4.3 Results

4.3.1 Behavioural outcomes

4.3.1.1 Patterns of behaviour across both conditions

Across both conditions, sensory behaviours were the most prevalent (3229 instances, with 94% of these being seeking behaviours), and mimicry was the least prevalent (194 instances). This pattern was replicated across all participants. There were similar numbers of RMBs (1334 instances), social behaviours (1321 instances), and enjoyment behaviours (1277 instances), with repetitive "hand/finger/foot" movements being the most prevalent RMB (68% of all RMBs), "showing" behaviours being the most prevalent social behaviour (56% of all social behaviours), and "smiling", the most common enjoyment behaviour (45% of all enjoyment behaviours). There were also similar amounts of gestures (471 instances), and anxiety behaviours (506), with the most prevalent gesture being “deictic” (71% of all gestures), and the most prevalent anxiety behaviour being irritability (37% of all anxious behaviours). When considering speech, there were 5712 utterances across the 19 children with verbal ability, with 81% being novel child speech, and 19% being child stereotyped/idiosyncratic speech. There were some individual behaviours that were less performed than others. For example, across the whole sample only three emphatic gestures were shown, and within the anxiety coding, only one physical complaint was made, and no participant cried. A full table of the frequency of all coded behaviours can be found in Appendix F.

4.3.1.2 Use of the iPad and touch, sound and light board in the control condition

In the control condition, the amount of time that the participants spent holding the iPad was coded, along with the frequency of sensory changes that occurred from presses on the iPad and touch, sound and light board. On average, participants held the iPad 11.4% of the time with some participants not holding the iPad at all. The longest the iPad was held by any participant was 7.8 minutes out of the total 15 minutes.

On average, 416.73 (*SD*=275.86) sensory equipment changes within the MSE were made using the iPad or touch, sound and light board during the 15 minutes, compared to 240 programmed sensory changes for each participant in the no control condition. However, some participants made less than 20 changes with others making more than 1000 changes across the 15 minutes. Further descriptive statistics can be found in Table 4.6.

Table 4.6. Descriptive statistics for iPad holding and Multi-Sensory Environment (MSE) changes from iPad and Touch, sound and light board presses in the Control condition. Each session lasted 15 minutes (900 seconds)

	Mean	SD	Median	Min.	Max.
iPad holding					
Frequency	6.05	4.44	5	0	16
Duration (s)	102.53	121.46	54.57	0	469.9
Sensory changes from iPad and touch, sound and light board presses					
Total	416.73	275.86	393	16	1458
Touch, sound and light board	153.17	94.83	140	2	415
Mirror ball*	60.69	57.43	44	7	286
Bubble tube	65.71	53.71	52	1	217
Fibre optics	57.59	80.28	34	0	441
Room lights	88.46	93.41	74	3	395

* *n*=41 for all equipment except mirror ball for which *n*=35, due to data loss.

A one-sample t-test demonstrated that there were more changes to the sensory environment in the control (*M*=364.93, *SD*=243.98) compared to the no control (*M*=240, *SD*=0) condition ($t(40)=3.28, p=.002, d_z=.51$). It must be noted that the sensory changes at the mirror ball were not included because it was different to the changes from other equipment (no control: continuous spinning lights around the MSE for three minutes; control condition: participant could turn it on and off). A repeated measures ANOVA found was no statistically significant change in the number of sensory changes over the course of the control condition ($F(1,34)=.50, p=.50, \eta^2=.02$).

Correlations investigated whether engagement with the iPad and Touch sound and light board associated with a reduction of behaviours involving the hands (Table 4.7).

Table 4.7. Spearman's Rho correlations of iPad holding duration and sensory changes from iPad and touch, sound and light board presses with repetitive motor behaviours (RMBs), sensory behaviour, gestures, mimicry and individual codes where the overall code is significant in the control condition.

Control condition	iPad holding duration	Sensory changes
Frequency RMBs	**-.30**	**-.21**
Duration RMBs	**-.36***	**-.20**
Duration whole-body RMBs	.26	-
Duration hand/finger/foot RMBs	-.30	-
Duration locomotion RMBs	-.48**	-
Frequency sensory	**-.20**	**.08**
Duration sensory	**-.23**	**-.11**
Frequency gestures	**.40****	**.33***
Frequency conventional	.08	.46**
Frequency informational	.41**	.24
Frequency emphatic	.27	-.02
Frequency deictic	.26	.22
Frequency mimicry	**.02**	**.39***
Frequency full mimic	-	.29
Frequency partial mimic	-	.35*

*p<.05, **p<.01, ***p<.001

There is evidence that the duration of RMBs may have been limited by the duration of iPad holding ($r_s=-.36, p<.01$), and even though it was not significant, there is a moderate effect of iPad holding duration on the frequency of RMBs. However, there is less evidence that sensory behaviours (frequency or duration) were affected by iPad holding.

More engagement with the iPad (longer iPad holding and more iPad presses) was significantly associated with more gestures, and more iPad presses was significantly associated with more mimicry. As those with higher abilities are likely to produce more gestures and mimicry, as well as engage more with the iPad, NVIQ was controlled for and these associations did not remain [iPad holding: gestures ($r=.16, p=.36$), or mimicry ($r=.04, p=.82$), and sensory changes: gestures ($r=.004, p=.98$), or mimicry ($r=.15, p=.40$)].

4.3.1.3 RMBs

RMBs were both fewer ($t(40)=-2.08, p=.04, d_z=-.32$) and shorter ($t(40)=18.65, p<.001, d_z=2.91$) in the control condition, compared to the no control condition (Figure 4.2).

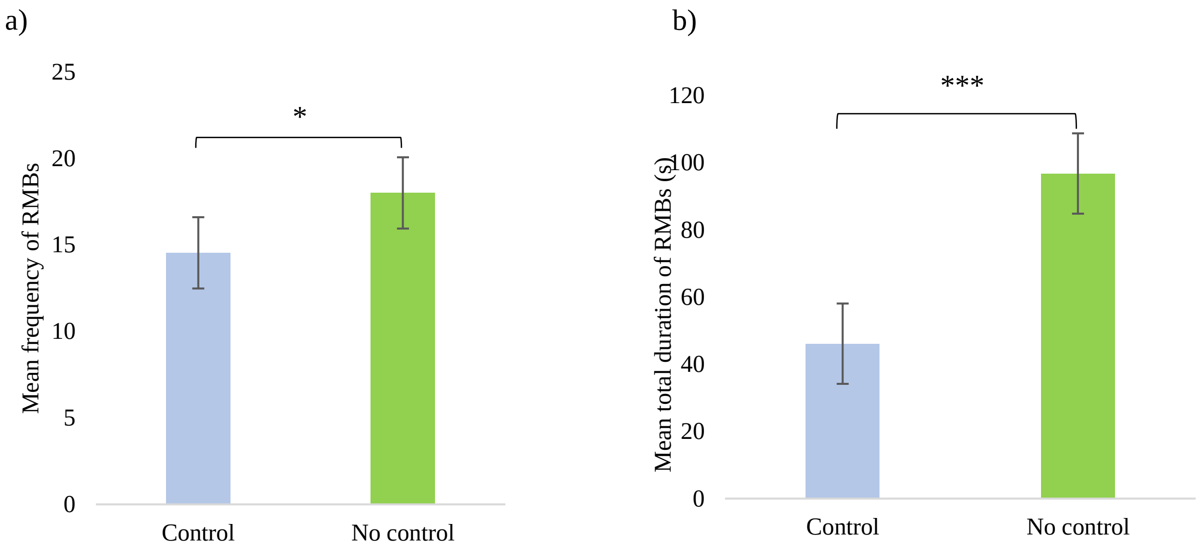
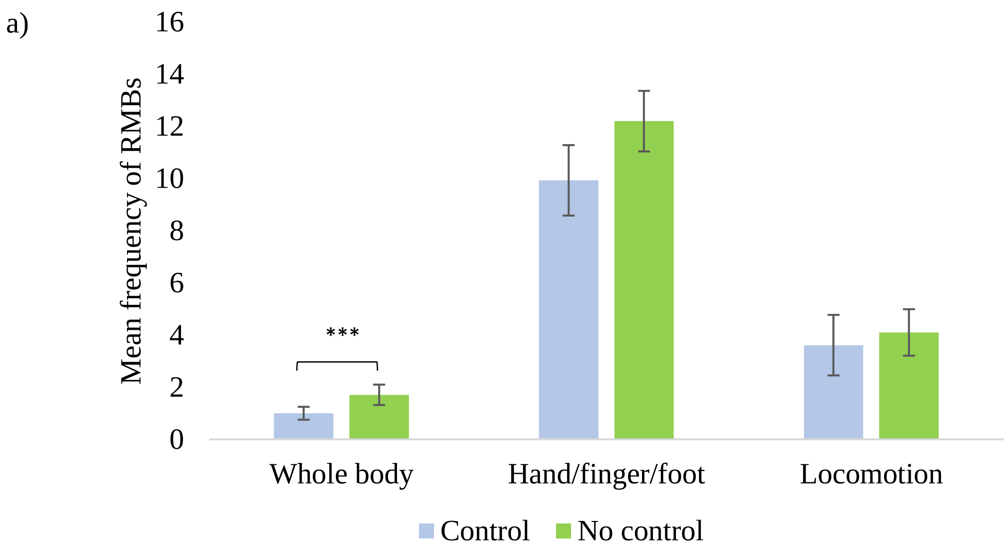


Figure 4.2. The mean, a) frequency, and b) total duration of Repetitive Motor Behaviours (RMBs) between the two conditions. Error bars represent standard errors. * *p*<.05, *** *p*<.001.

Post-hoc analyses investigated the pattern of frequency and duration for the individual RMBs codes (Figure 4.3).



b)

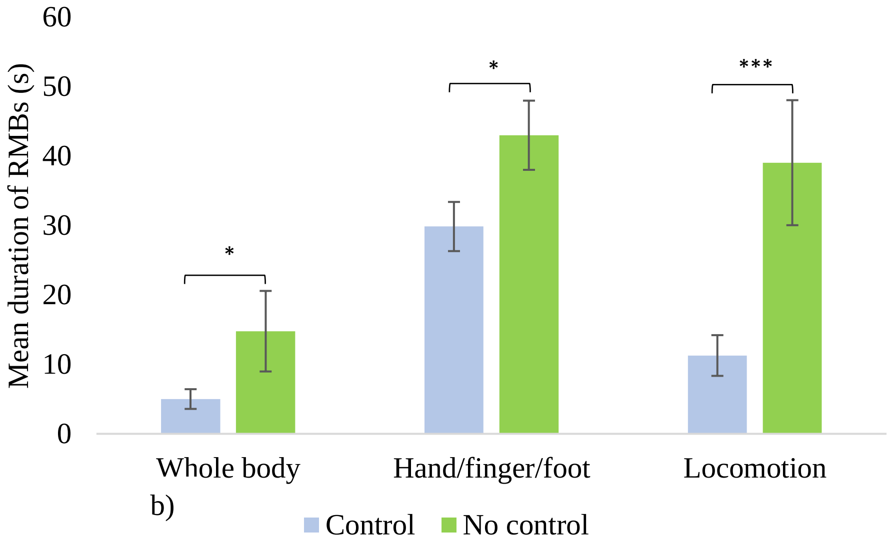


Figure 4.3. The mean, a) frequency, and b) duration of the individual Repetitive Motor Behaviours (RMBs) in the control and no control conditions. Error bars represent standard errors. * *p*<.05, *** *p*<.001.

There were fewer ($t(40)=16.16, p<.001, d_z=2.52$) and shorter ($Z=-1.98, p<.05, r=-.31$) repetitive whole-body movements in the control condition. The duration of repetitive hand/finger/foot ($t(40)=-2.47, p<.05, d_z=-.39$) and locomotion ($t(40)=66.95, p<.001, d_z=10.46$) movements were also significantly shorter in the control condition. However, there was no difference in the frequency of either repetitive hand/finger/foot ($t(40)=-1.88, p=.07, d_z=-.29$) or locomotion ($Z=-1.29, p=.20, r=-.20$)

Due to their association in the literature, RMBs were correlated with the frequency of anxiety and enjoyment in both conditions respectively, and with iPad holding duration controlled for in the control condition (Table 4.8).

Table 4.8. Spearman's Rho correlations of the frequency and duration of repetitive motor behaviours (RMBs) with the frequency of anxiety and enjoyment each condition respectively, ** *p*<.01.

					iPad holding duration partialled out	
	No Control Anxiety	**No Control Enjoyment**	**Control Anxiety**	**Control Enjoyment**	**Control Anxiety**	**Control Enjoyment**
Frequency RMB	-.03	.14	.29	-.04	.58**	-.08
Duration RMB	-.12	.29	.14	-.04	.26	-.06

4.3.1.4 Sensory behaviour

There were significantly fewer sensory behaviours in the control condition ($M=35.46$, $SD=17.80$) compared to the no control condition ($M=43.29$, $SD=18.63$), $t(40)=-2.82, p=.007, d_z=-.44$.

Likewise, the sensory behaviours were shorter in duration in the control condition (*M*=147.87, *SD*=94.53), compared to the no control condition (*M*=297.29, *SD*=167.30), $t(40)=15.53, p<.001, d_z=2.43$.

Post-hoc analysis of the sensory sub-codes showed that there were fewer ($t(40)=-2.75, p<.01, d_z=-.43$), and shorter lasting ($t(40)=16.22, p<.001, d_z=2.53$) seeking behaviours in the control condition, compared to the no control condition. In contrast, there were very few defensive behaviours in either condition and no difference in the frequency ($t(40)=-.92, p=.36, d_z=-.14$) or duration ($t(40)=-.32, p=.19, d_z=-.05$) of these behaviours (Figure 4.4).

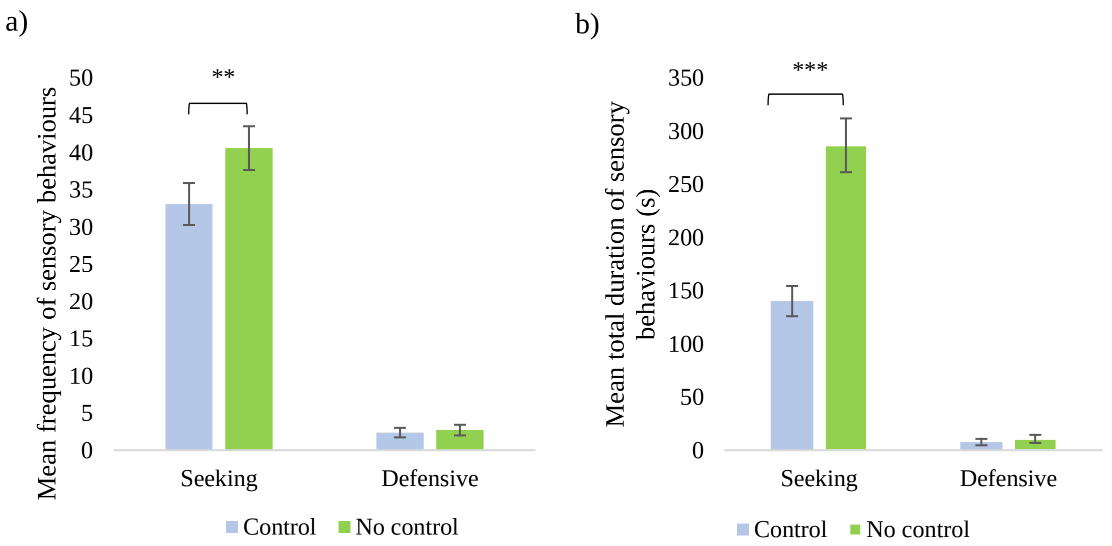


Figure 4.4. The mean, a) frequency and b) total duration of seeking and defensive behaviours across conditions. Error bars represent standard error. ** $p<.01$, *** $p<.001$.

Sensory seeking behaviours were not correlated with iPad presses ($r_s=.07, p>.05$).

There were no significant correlations between the difference in sensory seeking behaviours and either enjoyment or anxiety (*r* range: -.06 - .12; all p >.05), nor when iPad holding was controlled in the control condition (*r* range: -.11 - .06; all p >.05).

4.3.1.5 Attention

A paired sample t-test showed that there was significantly more attention paid in the control condition, compared to the no control condition, $t(40)=-3.73, p<.001, d_z=-.58$ (Figure 4.5).

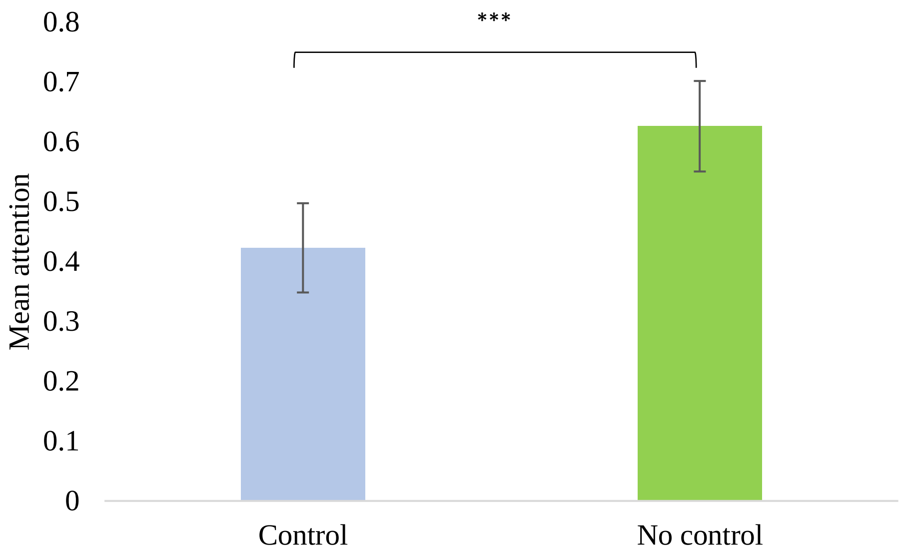


Figure 4.5. Mean attention score between the control and no control condition. Note a low score indicates more attention paid. Error bars represent standard error. *** $p<.001$.

Post-hoc analyses showed that attention at the touch, sound and light board was significantly greater in the control condition compared to the no control condition ($t(40)=-3.76, p<.001, d_z=-.59$). However, there was no difference in attention on either the bubble tube ($t(40)=-.57, p=.57, d_z=-.09$) or fibre optics ($t(40)=-1.36, p=.18, d_z=-.21$) between condition (Figure 4.6). As described in Chapter 3, it was not possible to obtain a reliable attention measure at the coloured lights or mirror ball.

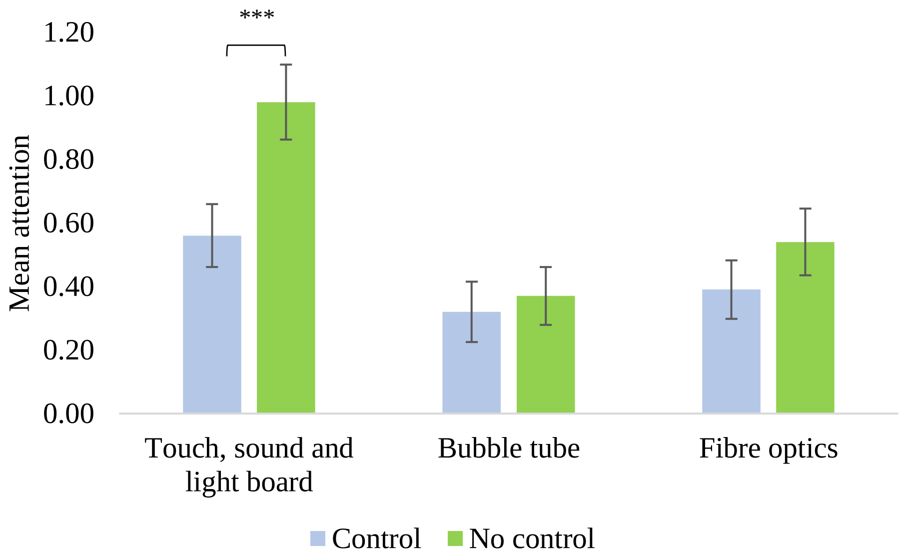
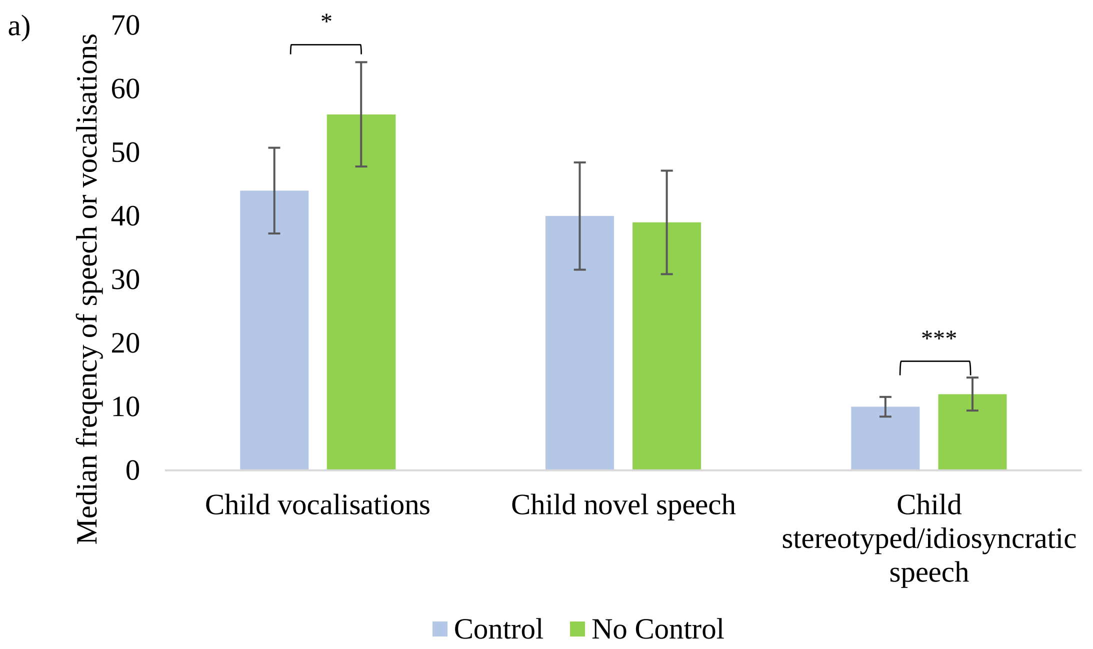


Figure 4.6. Mean attention at each piece of equipment. Error bars represent standard error. *** $p<.001$.

Higher levels of attention in the control condition were significantly correlated with lower frequency of RMBs in the control condition ($r_s=.37$, $p<.05$). However, there was no significant correlation between attention and duration of RMBs or frequency and duration sensory behaviours in the control or no control condition (*r* range: -.02 - .21; all p >.05).

4.3.1.6 Speech

Speech was compared between the control and no control conditions (Figure 4.7).



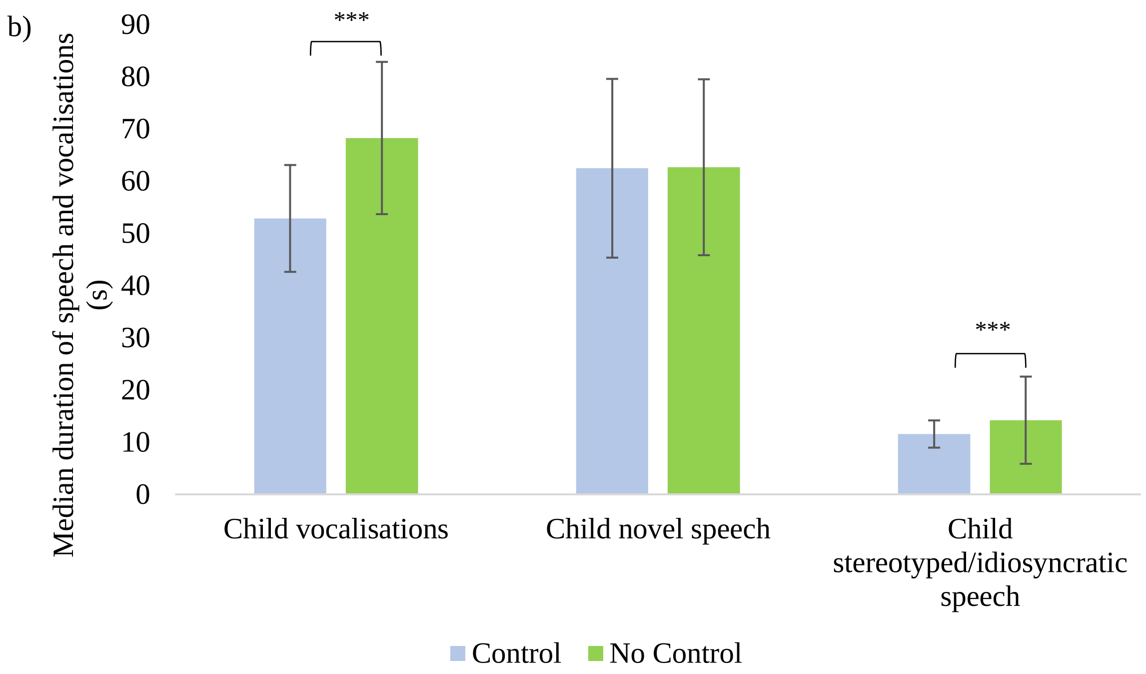


Figure 4.7. The median a) frequency, and b) duration of speech and vocalisations between conditions. Error bars represent standard errors. * *p*<.05, *** *p*<.001.

A paired samples t-test on the frequency data and a one-sample t-test on the transformed difference scores of the duration data demonstrated that there were fewer ($t(40)=-10.66, p=.02, d_z=-1.66$), and shorter ($t(40)=20.79, p<.001, d_z=3.25$) child vocalisations in the control condition compared to the no control condition. One-sample Wilcoxon Signed Ranks tests of the transformed difference scores of the frequency and duration of stereotyped/idiosyncratic speech. There were fewer ($Z=5.51, p<.001, r=.86$) and shorter ($Z=5.51, p<.001, r=.86$) stereotyped/idiosyncratic speech in the control condition compared to the no control condition. However, there was no difference in the frequency ($Z=-.01, p=.97, r=.00$) or duration ($Z=-.43, p=.67, r=-.07$) of child novel speech between conditions (Figure 4.7).

4.3.1.7 Social communication

There was no significant difference in social behaviours ($t(40)=-.66, p=.52, d_z=-.10$), mimicry ($t(40)=-1.73, p=.09, d_z=-.27$) or gestures ($t(40)=-1.78, p=.08, d_z=-.28$) between the control and no control conditions (Figure 4.8), indicating being in control of the MSE had no significant effect on social communication.

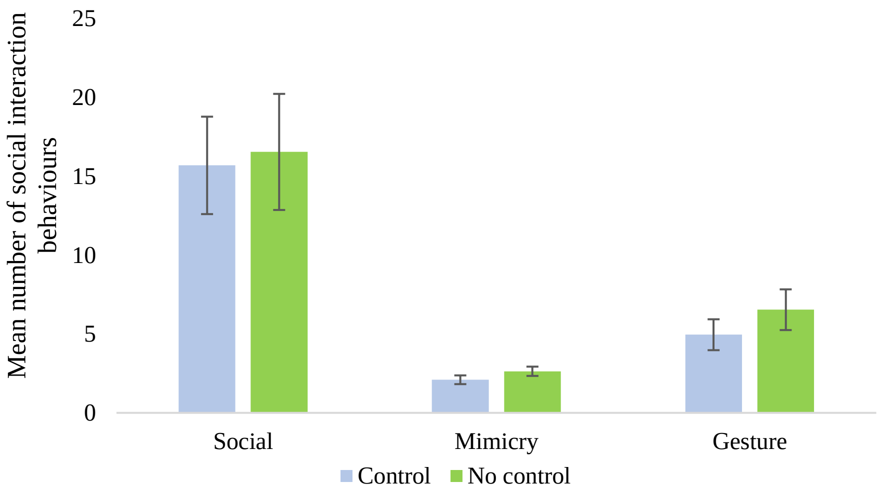


Figure 4.8. Mean social interaction behaviours between the control and no control conditions. Error bars represent standard errors.

Mean scores for the individual codes that comprised the three outcome variables can be found in Appendix G.

4.3.1.8 Rapport

The global ratings of rapport (range 0-2) were similar across the control (M=1.73, SD=.95) and no control condition (M=1.78, SD=1.08), $t(40)=-.53, p=.60, d_z=-.08$. On average, the level of rapport was closest to “One-sided or unusual interaction resulting in a consistently mildly uncomfortable session” in both conditions (the maximum score of 2).

4.3.1.9 *Anxiety and enjoyment*

There was no difference in the overall frequency of anxiety ($t(40)=-1.24, p=.22, d_z=-.19$) or enjoyment ($t(40)=1.65, p=.11, d_z=.26$) behaviours between conditions (Figure 4.9), with mean scores for the individual codes in Appendix H. Anxiety and enjoyment were also rated in each condition using global codes (0-2, where 0 is "no or mild and occasional anxiety/enjoyment is shown"). There was also no difference in global anxiety ($Z=-1.16, p=.25, r=-.18$) or enjoyment ($Z=-.61, p=.54, r=-.10$) score between conditions (Figure 4.10).

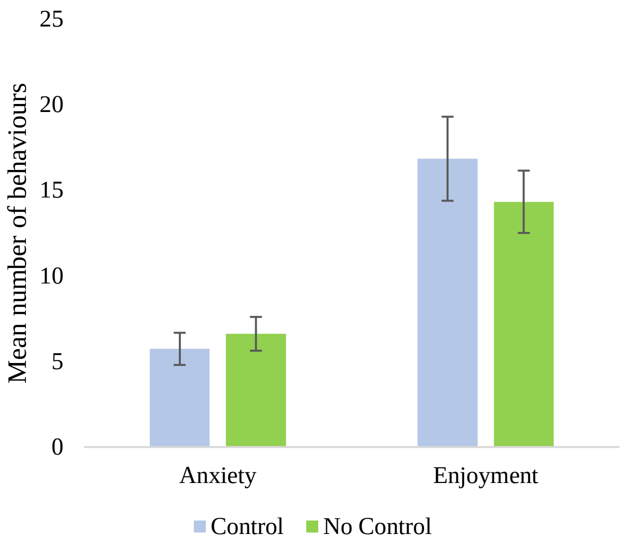


Figure 4.9. The mean frequency of anxiety and enjoyment behaviours in the control and no control condition. Error bars represent standard error.

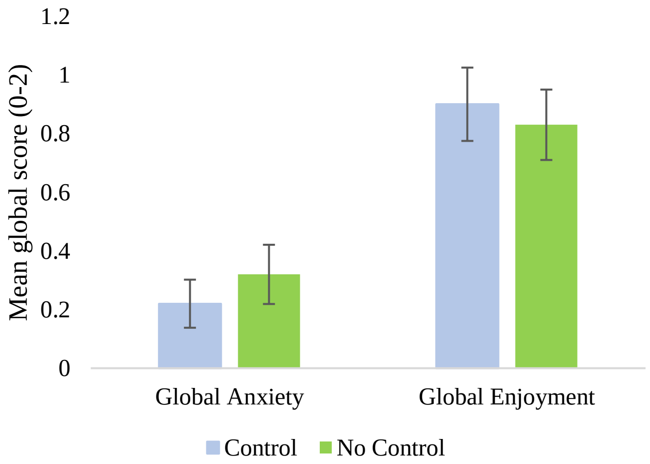


Figure 4.10. The mean global anxiety and enjoyment scores (0-2) in the control and no control condition. Error bars represent standard error.

4.3.2 Arousal

A repeated measures ANOVA showed a main effect of condition on RMSSD ($F(2,38)=3.70, p=.03, \eta^2=.16$). Post-hoc tests found a significantly lower RMSSD (higher arousal) for the baseline condition compared to both the control ($t(19)=-2.10, p<.05, d_z=-.47$), and no control ($t(19)=-2.45, p<.05, d_z=-.55$) conditions. There was no significant difference between the control and no control conditions, $t(19)=-.77, p=.45, d_z=-.17$ (Figure 4.11).

Inspection of the data at an individual level revealed that 55% of the 20 participants with HRV data had low arousal (i.e. high HRV) in both MSE conditions, and high arousal at baseline, with 20% of participants showing the opposite effect (i.e. high arousal in both MSE conditions and low arousal at baseline). 25% of the participants showed neither pattern.

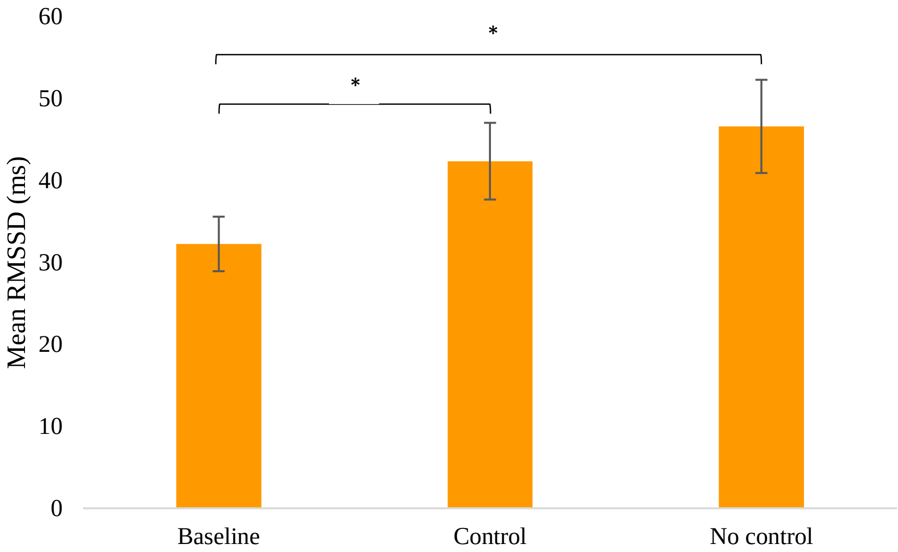


Figure 4.11. Bar graph of mean heartrate variability (as measured though Root Mean Square of the Successive Differences) across the baseline, control and no control conditions. Error bars represent standard error. * $p<.05$.

A repeated measures ANOVA showed a main effect of condition on activity levels ($F(2,38)=5.41, p<.01, \eta^2=.22$). Post hoc tests established less activity in the control compared to the no control condition, $t(19)=-2.15, p<.05, d_z=.48$. There was also less activity in the baseline condition compared to the no control condition ($t(19)=-2.86, p=.01, d_z=-.64$). However, baseline activity was not significantly different to activity in the control condition ($t(19)=-1.33, p>.05, d_z=-.30$) (Figure 4.12).

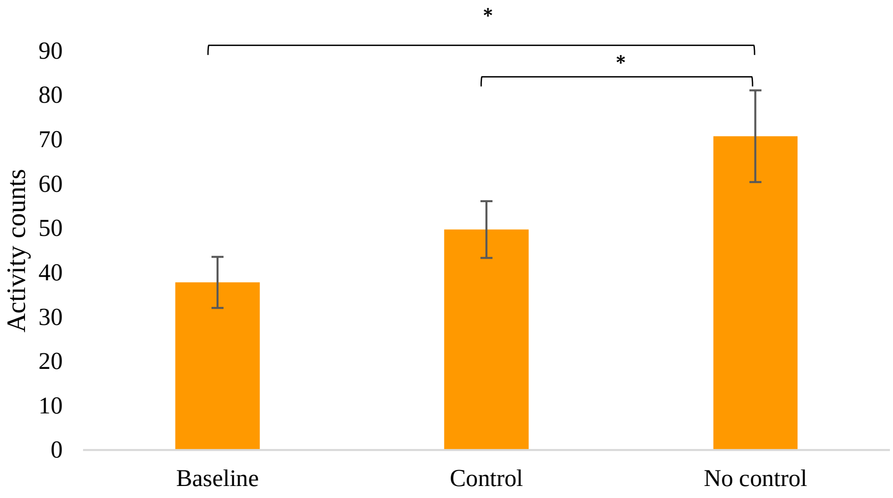


Figure 4.12. Bar graph of activity level (as measured from accelerometery data) across the baseline, control and no control conditions. Error bars represent standard error. * *p*<.05.

4.3.3 Parent report of behaviours

Parents completed eight questionnaires about their child's behaviour in every-day life, with the data summarised in Table 4.9.

Table 4.9. Scores of parent-report questionnaires (brackets indicate range of possible scores)

	N	Mean	SD	Range
Autism severity				
Social Communication Questionnaire (SCQ; 0-39)	40	24.8	6.48	9-35
Anxiety				
Anxiety Scale for Children -ASD total (ASC-ASD; 0-72)	39	19.1	12.81	0-55
Spence Children's Anxiety Scale total (SCAS; 0-114)	37	25.92	16.92	2-69
Intolerance of Uncertainty total (IOU-12P; 12-60)	39	32.56	10.7	16-57
RRBs				
Repetitive Behaviour Questionnaire-2 total (RBQ-2; 20-60)	39	41.44	7.33	22-55
RBQ-2 Motor/Sensory behaviour sub-scale mean score (1-3)	41	2.15	0.41	1-2.88
RBQ-2 Insistence on sameness sub-scale mean score (1-3)	41	2.01	0.49	1.11-2.78
Sensory				
Sensory Experiences Questionnaire total (SEQ; 32-160)	40	91.15	15.71	66-135
Sensory profile - Registration (SP; 15-75)	38	50	12.71	15-57
Sensory profile - Seeking (SP; 26-130)	32	79.62	17.35	41-113
Sensory profile - Sensitivity (SP; 20-100)	32	62.84	12.48	34-85
Sensory profile - Avoiding (SP; 29-145)	30	87.37	19.07	40-124
Attention				
ADHD scale total (0-78)	40	46.10	13.43	12-78

There was no significant correlation between the observations of anxiety in the control and no control conditions, and the three anxiety questionnaires; ASC-ASD, IOU-12P and SCAS (r range = -.22 - .14, $p>.05$). There were no significant relationships between the RBQ-2 Motor/Sensory behaviour sub-scale and RMBs in the control ($r=.02, p=.93$) or no control ($r=.12, p=.48$) condition, nor sensory behaviours in the control ($r=.04, p=.82$) or no control ($r=.10, p=.53$) condition. Neither were there significant relationships between the sensory variables and related questionnaires, SEQ and SP (r range = -.18 - .27, $p>.05$). Considering that the SP subscales were specific to sensory behaviour types, more fine-grained analyses were run. However, there was no significant correlation between SP Seeking subscale and the observational measure of sensory seeking in the control ($r_s=.10, p=.57$) or no control ($r_s=.18, p=.32$) conditions. Similarly, there was no significant correlation between SP Avoiding with the observational measure of defensive behaviour in the control ($r_s=-.10, p=.59$) or no control ($r_s=.10, p=.59$) conditions. There was a significant positive correlation between observed overall attention and the ADHD rating total scores in the no control ($r_s=.36, p<.05$), but not in the control ($r_s=.09, p=.60$) condition.

4.4 Discussion

This is the largest study to date of the effect of MSEs on autistic children and the first study to assess the effect of having control over the MSE on their behaviour, cognition and mood. Assessing 41 4-12 year old autistic children, having control over the sensory environment led to a reduction in RMBs and sensory seeking behaviours and an improvement in attention, compared to a condition where sensory changes were made independent of the participant. This supports the views of practitioners in Chapter 2 who believed that the child having control in the MSE leads to positive benefits. However, there was more limited evidence of a change in social communication behaviours, with stereotyped/idiosyncratic speech and vocalisations reducing but no evidence of an increase in positive social communicative behaviours. Anxiety, enjoyment and levels of arousal were also unaffected by condition.

The present findings have added to the small body of work investigating the effect of different types of MSE use on behaviour (Fava & Strauss, 2010; Glenn et al., 1996; Hill et al., 2012). Stereotyped behaviours and RMBs appear particularly amenable to intervention within the MSE as, including the current study, three out of four studies investigating MSE use found reductions in stereotyped behaviours when the MSE was used optimally (Fava & Strauss, 2010; Glenn et al., 1996). Although these data suggest that a reduction in stereotyped behaviours can be achieved through different types of MSE use, the varying diagnoses and small sample sizes of some studies need to be considered. For example, social interventions such as caregiver interaction (e.g. Glenn et al., 1996) may not be as effective as having control in autistic children.

Hill et al. (2012) also investigated engagement and found that the engagement of children with ID was higher when the caregiver provided high levels of attention within the MSE. Engagement was measured by coding the frequency of times the participant oriented to, or interacted with, the MSE equipment, making it conceptually similar to the measure of attention in the current study. Therefore, there is suggestion that both social intervention and having control of equipment can facilitate levels of attention in the MSE. Finally, Glenn et al (1996) found that social interaction within the MSE improved emotional state, pro-social behaviour and enjoyment, none of which were modulated by the children having control in the current study. However, Glenn et al (1996) assessed ID children, whilst the present study included autistic children with a range of intellectual abilities. As such, children with different profiles of strengths and difficulties may respond differently to different types of MSE use. Considering these findings together, there is evidence that some types of MSE use may bring benefit, but further research is required to compare the relative effects of these different methods of use. Such investigations could establish whether certain types of MSE use are best for facilitating particular types of behaviour or best suited to certain types of child.

4.4.1 Outcomes improved in the control condition

Various theories may explain why being in control of the MSE leads to behaviour change, including sensory needs being met (e.g. Lane et al., 2010; Baillon, 2002), improved predictability (e.g. Boulter et al., 2014; Eijgendaal et al., 2010; Pellicano & Burr, 2012), and the child feeling in control (e.g. Fattore et al., 2009), or a combination of all these.

Sensory behaviours and RMBs have been described as occurring in direct response to unusual or aversive sensory experiences to meet sensory needs (e.g. Ben-Sasson et al., 2008; Leekam, Prior, & Uljarevic, 2011). Both sensory behaviours and RMBs reduced in the control condition and it can be theorised that having control of the MSE is enabling sensory needs to be better met, thereby reducing the need for these behaviours. However, caution needs to be taken when describing a reduction in RMBs and sensory seeking behaviours as positive as it assumes that autistic individuals want to stop engaging in RMBs and sensory seeking behaviours. Both qualitative and quantitative research has described that engaging in RMBs (e.g. Joyce, Honey, Leekam, Barrett, & Rodgers, 2017; Wigham et al., 2015) and sensory behaviours (e.g. Joosten & Bundy, 2010) is associated with anxiety. However, engaging in RMBs has also been linked to enjoyment (Harris, Mahone, & Singer, 2008; Mahone, Bridges, Prahme, & Singer, 2004). In semi-structured interviews with autistic individuals, Joyce et al. (2017) reported that nine out of their ten participants enjoyed engaging in RRBs, but some also reported that RRBs were only enjoyable as they helped manage anxiety. The presence of sensory behaviours have also been described anecdotally as both enjoyable and distressing (Jones, Quigney, & Huws, 2003). Indeed, the potential pleasure derived from sensory behaviours has been recognised in Dunn's (1997) Sensory Profile questionnaire, which includes enjoyment of sensory seeking behaviours. However, within this study there was limited evidence of an association between RMBs and sensory behaviours with anxiety or enjoyment. The only significant finding was that RMBs were significantly positively correlated with anxiety when iPad holding was controlled, therefore, suggesting that RMBs may be reduced when the participant has control because of an associated reduction in anxiety. It remains that the practitioner working with the autistic child within the MSE must ascertain if a reduction in RMBs or sensory seeking behaviours may be beneficial for the child, and if so, they can use providing control of the MSE as a tool for potentially reducing these behaviours.

IoU is known to effect both RMBs and anxiety (e.g. Boulter et al., 2014), although there was no overall effect of being in control on reducing anxiety. It is possible that improvement in IoU was not substantial enough to reduce anxiety behaviours in the control condition. However, the correlation between lower anxiety and lower levels of RMB in the control condition when iPad holding is controlled for is compatible with a reduction in IoU following improved predictability of sensory changes. Likewise, it is possible that being in control of sensory equipment had a strong effect on intolerance of sensory uncertainty, leading to improvement in relatively closely related outcomes such as RMBs. In contrast, intolerance of social uncertainty remained unchanged, explaining the limited effect on anxiety and social behaviour.

Learning for autistic people is reduced by the presence of RRBs (Joosten & Bundy, 2010; Koegel & Covert, 1972; Lancioni, Singh, O'Reilly, & Sigafoos, 2009; Leekam et al., 2011; Rodgers, Glod, Connolly, & McConachie, 2012). Indeed, poor attention has also been associated with poorer than expected academic outcomes in children with a mix of typical development and clinical diagnoses, including autism (e.g. Mayes & Calhoun, 2007). Therefore, as the reduction in RMBs in the control condition was positively associated with an increase in attention, these findings could suggest that having control of the MSE may provide strong conditions for learning. Another potential positive indicator for the possibility of improved learning in the control condition is that activity levels were reduced, and some research has shown that excess gross motor activity can negatively affect learning (e.g. Reichenbach, Halperin, Sharma, & Newcorn, 1992). The speculative effects of MSEs on learning reflects the beliefs of practitioners in Chapter 2, who reported that when the MSE meets sensory needs a barrier to learning is removed. In fact, previous qualitative (Ayre, 1998; Stephenson & Carter, 2011) and quantitative studies (Houghton et al., 1998; Mey et al., 2015) have suggested that the MSE may be beneficial for learning. To date no studies have specified the mechanisms or behavioural changes which enable improved learning within the MSE, yet the present study does provide some insight. Therefore, considering the present and previous findings together, the MSE may hold particular promise for positively impacting learning in its users, and specifically in autism, this may be due to the MSE reducing RMBs and activity and improving attention.

Having control of the MSE reduced vocalisations and stereotyped/idiosyncratic speech, but other social communication and interaction variables (i.e. social behaviours, gestures, mimicry, novel speech and rapport) remained unchanged. There has been limited research on stereotyped/idiosyncratic speech (see Van Santen, Sproat, & Hill, 2013), with research generally focussing on RRBs and echolalia without considering the other aspects of stereotyped/idiosyncratic speech, including reciting non-personal facts and speaking in the third person. Echolalia, which was encapsulated in the stereotyped/idiosyncratic speech code, is understood to impede social interactions for autistic people (Schreibman & Carr, 1978). However, concomitant improvement in social behaviours or communicative speech from a reduction in stereotyped/idiosyncratic speech in the current study were not observed. Although the experimental design of the current study enabled unlimited spontaneous social interaction it was more limited in offering the participant the opportunity to respond as experimenter speech was controlled.

The reduction in vocalisations in the control condition is also difficult to interpret. The vocalisations code included two types of vocalisation; communication and sensory seeking vocalisations. Communicative vocalisations were sounds that are not recognised English words but have communicative intent (e.g. exclaiming “Hmm’ to indicate thinking). In contrast, sensory seeking vocalisations involve production of often very similar sounds to provide sensory stimulation (e.g. humming to provide low auditory stimulation). The communicative intent of vocalisations could not be reliably inferred from the behavioural observations, therefore it was not possible to measure the two types of vocalisation independently. A reduction in sensory seeking vocalisations would be in-line with the reduction in overall sensory seeking in the control condition, and anecdotally, most of the vocalisations within the MSE seemed to have a sensory seeking, rather than communicative quality, but further interpretations are not possible.

4.4.2 Outcomes unaffected in the control condition

Although control of the MSE is associated with some putatively positive changes that relate to cognition and behaviour, there were no differences between conditions in levels of anxiety, enjoyment and arousal. Neither were there differences in a range of social interaction and communication behaviours including, social behaviours, gesture, mimicry, rapport and novel child speech. This does not concur with the interviewed practitioners (Chapter 2), who believed that a reduction in anxiety typically preceded other positive effects.

An important consideration when interpreting the findings is that the study presented the participants with novel or unusual experiences including coming to a research centre, using the MSE, working with a previously unknown adult, as well as ability and ADOS-2 assessments. Insistence on sameness is a core symptom of autism (APA, 2013) and, as previously mentioned, IoU is strongly associated with autism (e.g. Boulter et al. 2014), both of which would predict overarching difficulty with the novelty of the testing day. Therefore, it is possible that anxiety was relatively high throughout the study rendering the experimental manipulation insensitive to change. However, arousal was significantly lower in both MSE conditions compared to the baseline condition, which was always administered first. This provides objective, physiological evidence that the participants did become more relaxed as the testing day progressed, bringing this interpretation into question.

Although a difference was found between baseline and both MSE conditions, levels of arousal did not differ between MSE condition. Shapiro et al. (1997) measured heart rate (HR) and found no group difference between an MSE and playroom condition but they did find individual differences in HR changes in response to MSE use. Evidence of individual differences in the effect of the MSE on arousal was also found in the current study, with just over half of participants showing higher arousal in both MSE conditions compared to the baseline, 20% showing lower arousal in both conditions compared to the baseline, and 25% showing neither pattern. Although this could not be investigated statistically due to data quality issues, these individual differences likely explain the lack of a main effect but may also explain why MSEs are described as being able to both calm and stimulate users (e.g. Kewin, 1994), that is, the effect of the MSE would depend on the starting arousal state and specific needs of the user. Echoing this, the practitioners in Chapter 2 suggested that the MSE can stimulate those who are passive and need to be stimulated, and calm those who are over-stimulated.

MSE condition also had no significant effect on most measures of social interaction. There has been some suggestion that being overwhelmed by sensory input due to hyper-sensitivity or needing to sensory seek to meet sensory needs may limit the engagement in social interactions (e.g. Hilton, Graver, & LaVesser, 2007). Therefore, it was hypothesised that sensory needs being met in the control condition may facilitate social communication and interaction. The lack of an effect may reflect that meeting sensory needs has limited effect on fundamental social cognitive difficulties such as difficulty understanding others' minds (e.g. Baron-Cohen, 2000).

The questionnaires on everyday child behaviour and symptomatology did not generally associate with the behaviours observed within the MSE in either condition. This could be because comparing parent-report of autistic behaviour with observation of such behaviour typically has poor agreement (De Bildt et al., 2004; Stone & Hogan, 1993). This is likely due to differing settings that the autistic individual is observed in (e.g. research centre versus home), and the amount of time they are observed for (e.g. every day by parent, 'trait' vs. one-off visit to the centre, 'state').

4.4.3 Limitations

Technical limitations of using commercial sensory equipment did not allow for modification of the rate of presentation of sensory changes in the no control condition to match the participants' engagement in the control condition. Although it is worth noting that this approach would have introduced order effects from presenting the control condition first so that sensory changes could be yoked. However, the current design meant there were significantly more sensory changes in the control condition and, therefore, it is not possible to determine whether it is the act of being in control, the resulting increase in sensory stimulation, or both that is facilitating behaviour change. Even though this issue limits interpretation of the findings, it is still clear that allowing the child to be in control, regardless of the mechanisms of action, leads to behavioural and cognitive change. Additionally, the data showed that when autistic children have control they chose to provide themselves with more sensory stimulation than was passively provided in the no control condition. Although a basic attraction to the mechanistic actions of the iPad and touch, sound and light board cannot be discounted, this is not likely as the amount of presses remained constant across the duration of the sessions rather than habituating. Indeed, this finding reflects data from the Sensory Profile showing that 71% of the participants had profiles of more, or much more, sensory seeking behaviours in everyday life compared to typically developing individuals.

Previous MSE experiences related to having control could have impacted the present findings. For example, as insistence on sameness is a symptom associated with autism (APA, 2013), if the child usually had control of the MSE, taking control away in the ‘no control’ condition could have increased anxiety. Indeed, as anxiety is suggested to be related to both RMBs and sensory behaviours (e.g. Boulter et al. 2014), this deviation in method of use could have also increased RMBs and sensory behaviours. However, as parents were not asked how their child usually uses the MSE (i.e. whether they usually had control), the impact of previous MSE experiences on present outcomes cannot be assessed.

Three minutes at each piece of equipment was chosen based on piloting and practical considerations concerning the overall length and number of sessions. However, as time spent within the MSE was not manipulated, it is unclear whether the length chosen was optimal for benefits to occur and null findings may reflect insufficient exposure. Further research that manipulates the length and amount of MSE sessions is necessary to provide insight into possible ‘dose effects’.

MSEs are often used on an individual basis, but as described by the practitioners (Chapter 2), they can also be used in groups. Considering the present findings, stimulation cannot be individually controlled when the MSE is used with a group, and so, to achieve the benefits described here, each child would have to take turns being in control. As the MSE is motivating (Chapter 2) this could support the development of turn-taking skills which could be generalised to other contexts, but as only one child would benefit at a time, this may not be an efficient use of the MSE. Therefore, a more pragmatic approach may be to use the MSE in a different way for groups. For example, as the practitioners described that being in the MSE gave a 'group feeling' and enabled the children to be more accepting of their peers (Chapter 2), a group social-skills intervention may be effective.

The anxiety measure was compiled using multiple validated sources (see Chapter 3). However, the coding process identified anxious behaviours, including subtle movements and facial expressions that were not captured in the coding scheme. Notably, subtle facial expressions could not be coded because of video quality. Therefore, the measure may not have been sensitive enough to detect effects. Additionally, feeling anxious does not always result in explicitly anxious behaviours. Although an objective physiological measure, HRV, was included, it was affected by data loss (quality issues, and participants refusing to wear the monitor). Combining HRV with other physiological measures of stress that are better tolerated (e.g. cortisol) in future studies could provide a more comprehensive representation of participant anxiety.

Although the overall measure of enjoyment was useful, the 'integrated singing and dancing' code meant separate instances of singing and dancing could not be coded. This specification was used to prevent interpreting ambiguous body movement as dancing (Murcia et al. 2010). However, other authors do not make this distinction (Blasing et al., 2012; Sevdalis & Keller, 2011), and dancing is, to some extent, dissociable from non-rhythmic body movements. In addition, both singing (e.g. Chong, 2010) and dancing (e.g. Wallbott, 1998) have been found to be individual indicators of enjoyment and therefore, this code should be divided into individual codes if used in future studies.

Enhanced Perceptual Functioning (i.e. superior visual and auditory functioning, Mottron & Burack, 2001) and hypo-reactivity (i.e. under-responsivity; APA, 2013) form part of autism sensory symptomatology. However, they were not measured here as this would require the administration of specific tasks or measuring the absence of a behavioural response (issues discussed in Chapter 3). It is a limitation of the present study that the full range of autistic sensory symptoms were not investigated.

As there was no comparison between MSE and non-MSE conditions, the present study cannot provide insight into the benefit of MSE use over engagement in a non-MSE (e.g. regular playroom). There are significant challenges in choosing an appropriate non-MSE condition as an environment with reduced sensory interest and stimulation is a poor control for the natural interest provided by an MSE.

4.4.4 Conclusions, implications and future directions

This study improved significantly upon the methodological rigour of most previous MSE studies. The study controlled for the number and type of equipment that was engaged with, for the amount of time spent with the equipment, for the amount of attention and interaction provided by the experimenter, and for familiarity by using a novel room and unknown experimenter. Control of sensory changes in the MSE led to a reduction in RRBs, including RMBs and sensory behaviours, coupled with increased attention, and a reduction in stereotyped speech and vocalisations. It can be suggested that having control of the MSE better enables autistic children to meet their sensory needs, resulting in a range of positive outcomes. It is also possible that predictable sensory changes created a less stressful environment, which facilitated behaviour change. The findings suggest some possibilities regarding how the MSE could be used to maximum benefit by practitioners. For example, increased attention and an associated reduction in RMBs from the child having control, along with decreased activity, may provide an enhanced opportunity for learning or for implementing therapies or interventions. In contrast, practitioners wanting to improve autistic children's communication may find that control leads to a reduction in stereotyped/idiosyncratic speech and vocalisations but should be aware that other social communicative behaviours are unlikely to change. Similar benefits may be possible from the child controlling other sensory experiences in non-MSE spaces in their home or school environment. Further research, including replication, is required before recommendations can be formalised but the findings suggest that basic manipulations in the way the MSE is used can have significant impact on autistic children's behaviours. Importantly, giving the child control is a simple, cost-free and easy to implement modification.

There is wide heterogeneity in the presentation of autism (APA, 2013), along with suggested behavioural sub-types (Wing & Gould, 1979), and these differences in symptomology imply that having control may have differentially impacted the participants. For example, for those with high sensory hyper-sensitivity, having control of the MSE would enable them to limit and predict the stimulation perhaps leading to positive behavioural change. Additionally, those who are generally under-stimulated may have benefitted from being able to provide themselves with more stimulation through being in control. Whereas, less severity in these symptoms (e.g. less severe hyper-sensitivity), or other symptoms not directly related to having sensory control (e.g. social symptoms), would suggest less benefit was gained from being in control. It is a limitation of the present study that the effect of individual differences on the impact of the MSE could not be investigated due to sample size. A larger-scale study with the capacity for sub-grouping and exploration of predictors of outcomes is needed as this could provide valuable insight into who benefits most from having control of the MSE. However, it must be noted that within the present study individual differences are likely to have resulted in high variability within the data, and yet differences were still found between the conditions. This indicates the robustness of the present findings and suggests that having control of the MSE is broadly beneficial despite individual differences.

This empirical investigation has given important insight into the effect of the child having control of the MSE. However, it does not provide information about how autistic children naturally choose to engage in MSEs, including their preferred equipment. Therefore, in Chapter 5 findings are presented about how the participants in this study chose to engage when they had free use of the MSE.

Chapter 5: The preference of autistic children for MSE equipment in a free play MSE session

5.1 Introduction

The study presented in Chapter 4 was a tightly controlled experiment and required the autistic children to use the MSE in a structured way, engaging with the equipment in a set order for a set duration. However, when MSEs first came to prominence, Snoezelen® was the standard practice (Hulsegge & Verheul, 1986), whereby the individual used the MSE freely without intervention from a practitioner or caregiver. Despite MSEs now being used in more structured ways for education (e.g. Stephenson & Carter, 2011), there is some evidence that a Snoezelen® approach is also still used (e.g. Carter & Stephenson, 2012).

The approach taken in Chapter 4, while providing rich information about the effect of control of the MSE on behaviour, provided no insight into autistic children's preferences within the MSE. The practitioners interviewed in Chapter 2 described the importance of knowing the preferred MSE equipment for their autistic pupils. They stated that the preferred equipment can be built into the pupils' work plans, to motivate them and facilitate learning outcomes or developmental goals. Koegel and Egel (1979) discuss that difficulties with motivation in autistic children can particularly affect learning. There has been some investigation into preferred MSE equipment for ID adults. Thompson and Martin (1994) sequentially presented each piece of equipment to six ID adults for twenty seconds, with the behavioural response to the equipment being coded as positive, negative or neutral. They found that the most preferred item was a plasma ball, assumed to be a clear ball containing coloured lights, and the least preferred item was a projector. In a larger study, Matson, Bamburg and Smalls (2004) investigated preference for MSE stimuli in 52 ID adults using a similar method to Thompson and Martin (1994). In contrast to Thompson and Martin, they found that a projector and mirror ball were the most preferred items. No study to date has investigated the preferences of autistic people for MSE equipment.

There is converging evidence that autistic people have a distinct sensory profile compared to those without autism (e.g. Ben-Sasson et al., 2009; Green, Chandler, Charman, Simonoff, & Baird, 2016). Indeed, there is also data suggesting that sensory profiles vary within autistic samples by age (e.g. Leekam, Nieto, Libby, Wing, & Gould, 2007), autism severity (e.g. Ben-Sasson et al., 2009), and IQ (e.g. Leekam et al., 2007). Sensory profiles dictate sensory needs and therefore different sensory profiles may align with distinct types of equipment (e.g. targeting a specific modality) or modes of engagement with equipment (e.g. preference for high intensity of input or for high frequency of sensory changes). Therefore, the present study will investigate whether characteristics of autistic individuals (sensory profile, age, IQ and autism severity) affect preference for particular equipment.

Only one study has investigated the effect of free play in the MSE on arousal (Shapiro et al., 1997). Shapiro et al. (1997) found that there was no difference in heart rate between their free play MSE and playroom conditions in their 20 ID child participants. However, there has been no investigation into physiological arousal and activity levels of autistic children in this setting. Both will be measured in the present study and compared to a baseline of free play in a standard playroom. It is expected that arousal levels will be lower (i.e. HRV will be higher) in the MSE free play session, reflecting previous findings of greater relaxation from MSE use (Chan et al., 2005; Mey et al., 2015).

To summarise, no study to date has investigated how autistic participants choose to engage in the MSE when allowed to explore freely, nor has the effect of this on arousal or activity been investigated. There is also evidence that preference could vary by characteristics such as age, IQ, autism severity and sensory profile. According to the interviewed practitioners (Chapter 2), this information is important for their practice as identifying motivating equipment may facilitate improved outcomes.

5.2 Methods

5.2.1 Participants

The present data were collected during the study presented in Chapter 4 and all participants were included. See Chapter 4 for participant details.

5.2.2 Design and materials

During this free play session, the participants could engage with four pieces of equipment in the MSE; the bubble tube, touch, sound and light board, fibre optics and tactile board. The tactile board was not included in the Chapter 4 study but was a wall-mounted panel, measuring 145 x 120cm, and contained a variety of materials with different textures (see Chapter 2). The LED room lights, and mirror ball were activated throughout, but engagement with them could not be coded as there was no focal point for sensory experience (i.e. the LED room lights, and mirror ball affected colour change across the entire MSE). The iPad was not available to the participants to enable investigation of attraction to the equipment without the confound of the iPad, which was not available for the touch, sound and light board or tactile board. The free play condition was video recorded with the same equipment described in Chapter 4.

HRV and activity were measured using the same monitor described in Chapter 4. The baseline condition described in Chapter 4 was used as a comparison condition for these physiological measurements.

Two parent report questionnaires, the SCQ and SP, were also included and are described in Chapter 4.

5.2.3 Procedure

The procedure for the baseline HRV free play session has been described in Chapter 4. Directly after the participant had completed their second MSE condition from the study described in Chapter 4 they engaged in a five-minute free play session in the MSE. All the equipment was turned on and the participant was able to use any equipment they chose for any amount of time within the five-minutes. Experimenter speech and engagement was unrestricted. The condition began by the experimenter explaining that the participant could play with anything they wanted. If the participant did not engage with a piece of equipment of their own accord, a piece of equipment was demonstrated to them by the experimenter along with some verbal encouragement.

5.2.4 Analysis plan

The frequency and duration of visits to each piece of the equipment was coded. The equipment a participant first chose to visit when they were not prompted by the experimenter was also noted as an additional measure of preference. The procedure for assessing normality described in Chapter 4 was used on the present data. A repeated measures ANOVA assessed if the frequency or duration of visits significantly differed between equipment, with post-hoc analyses used as appropriate. Participant characteristics such as age, IQ (represented by NVIQ), autism severity (represented by ADOS-2 comparison score and total SCQ score) and sensory profile (represented by SP quadrant score and sensory seeking behaviours) were correlated with the frequency and duration of visits to equipment. Activity and HRV were compared between the baseline and free play sessions.

5.3 Results

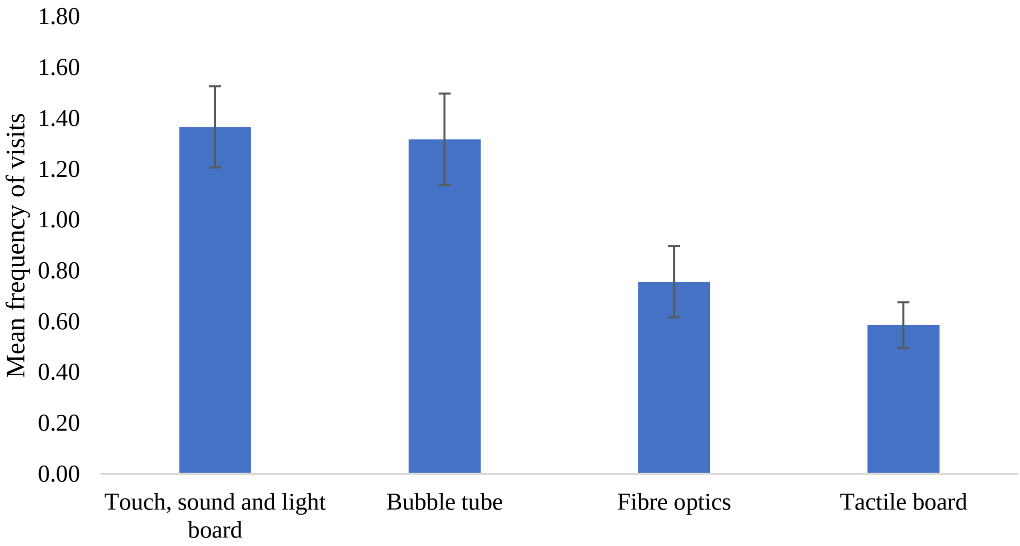
5.3.1 First visit and frequency and duration of visits to the equipment

Eight participants (20%) engaged with the equipment throughout the whole of the free play session, with the majority of participants (n=23, 56%) engaging for between 80-99% of the total available time. Only 4% (n=2) of the sample engaged for less than 50% of the session.

Twenty-one of the 41 participants (51%) did not need a prompt to initially engage with the equipment. For these participants, the bubble tube was the first piece of equipment that most (48%) engaged with, followed by the touch, sound and light board (37%), the fibre optics (11%) and the tactile board (4%).

On average the participants made 4.02 (SD=2.50) visits to the equipment, which could include returning to the same equipment. Across the whole five-minute session, participants were engaged with equipment for an average of 4.3 minutes (*SD*=57.88 seconds). The mean frequency and duration of visits to each piece of equipment are presented in Figure 5.1.

a)



b)

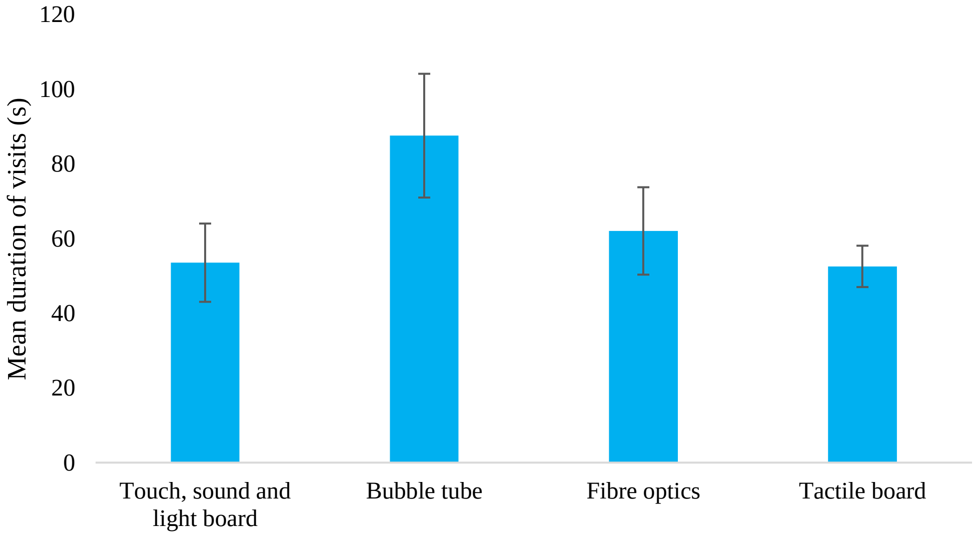


Figure 5.1. The mean, a) number, and b) duration of visits to each piece of equipment in the MSE during the five-minute free play session. Error bars represent standard errors.

A repeated measures ANOVA demonstrated that there were differences in both the frequency ($F(3,120)=10.90, p<.001, \eta_p^2=.20$) and duration ($F(1.91,76.45)=8.29, p<.001, \eta_p^2=.17$) of visits to the different equipment in the MSE. Post-hoc comparisons (Bonferroni corrected, Table 5.1) demonstrated that the bubble tube was the most popular item as it was visited significantly more frequently and for longer than all other items. The touch, sound and light board was also very popular and there was no significant difference to the bubble tube in how frequently it was visited, or for how long. The tactile board was the least popular piece of equipment, although it was visited as often and for a similar length of time to the fibre optics (all p <.05).

Table 5.1. Post-hoc comparisons of the frequency and duration of visits to the four pieces of equipment, *p<.05, **p<.01, ***p<.001 (Bonferroni corrected)

Equipment comparisons		**Frequency (mean difference)**	**Duration (mean difference)**
Touch, sound and light board	vs. Bubble tube	.05	-45.44
	vs. Fibre optics	.61**	22.95
	vs. Tactile board	.78***	43.93***
Bubble tube	vs. Fibre optics	.56*	68.39*
	vs. Tactile board	.73*	89.37***
Fibre optics	vs. Tactile board	.17	20.98

5.3.2 Impact of participant characteristics on the preference for equipment

The higher the participants' NVIQ, the longer they spent at the touch, sound and light board (r_s=.37,p=.03) and tactile board (r_s=.45,p=.007), and the less time they spent at the bubble tube (r_s=-.50,p=.002). Time spent at the fibre optics was not related to NVIQ, and there were no associations between autism severity and the percentage duration at any piece of equipment.

Age was positively associated with time spent at the tactile board (r_s=.42,p=.007), but was not related to time spent at the other equipment (range r_s=-.20 - .12,p=.21 - .60). Given time spent at the tactile board correlated with both NVIQ and age, partial correlations were run. They showed NVIQ still correlated with time spent at the tactile board with age controlled (r=.36,p=.04) but age no longer correlated with time spent at the tactile board when NVIQ was controlled (r=.20,p=.26).

SP quadrant scores (note, the lower the sensory profile score, the higher the sensory symptoms) were also correlated with equipment durations (Table 5.2). There was limited evidence of meaningful effect sizes. However, duration at the equipment was significantly related to the SP Sensory Sensitivity quadrant, with a higher amount of sensory sensitivity being associated with less time spent at the bubble tube, but more time being spent at the tactile board.

Table 5.2. Spearman's Rho correlations between the duration of time spent at equipment and sensory profile quadrant scores, *p<.05, **p<.01.

	Duration spent at equipment			
Sensory profile quadrant scores	Touch, sound and light board	Bubble tube	Fibre optics	Tactile board
Registration	-.25	.17	-.05	-.30
Avoiding	-.21	.25	.03	-.34
Seeking	.05	.08	-.08	-.11
Sensitivity	-.20	.35*	-.06	-.47**

Owing to the very small number of sensory defensive behaviours performed in the free play session (*M*=1.39, *SD*=2.33), only correlations between equipment engagement and sensory seeking (frequency: *M*=12.68, *SD*=9.21; duration: *M*=89.80, *SD*=91.07) will be investigated here (Table 5.3). Correlations were also run with NVIQ partialled out as it correlated with both the frequency (r_s=-.48,p=.004) and duration (r_s=-.52,p=.001) of sensory seeking behaviours.

Table 5.3. Spearman's Rho correlations of the frequency and duration of sensory seeking behaviours performed in the free play session correlated with the frequency and duration of visits to the four available pieces of Multi-Sensory Environment (MSE) equipment, and with Non-Verbal Intelligence Quotient (NVIQ) partialled out, *p<.05, **p<.01, ***p<.001

		Sensory seeking frequency	**Sensory seeking frequency** (NVIQ partialled)	**Sensory seeking duration**	**Sensory seeking duration** (NVIQ partialled)
Touch, sound and light board	Frequency of visits	-.22	-.10	-.42**	-.40*
	Duration of visits	-.38*	-.11	-.60***	-.47**
Bubble tube	Frequency of visits	.53***	.20	.43**	.07
	Duration of visits	.68***	.44**	.76***	.55***
Fibre optics	Frequency of visits	-.31*	-.25	-.30	-.27
	Duration of visits	-.29	-.22	-.26	-.19
Tactile board	Frequency of visits	-.37*	-.29	-.43**	-.41*
	Duration of visits	-.41**	-.23	-.45**	-.24

When NVIQ was partialled out, only some significant associations remained. The less time spent engaging in sensory seeking behaviours, the more visits were made to the tactile board and touch, sound and light board, and the longer was also spent at the touch, sound and light board. In addition, the more and longer the sensory seeking behaviours produced, the more time was spent at the bubble tube.

5.3.3 Activity and arousal during the free play session

There was significantly more activity in the free play condition compared to the baseline condition, $t(11)=-4.40, p<.001, d_z=-1.27$ (Figure 5.2).

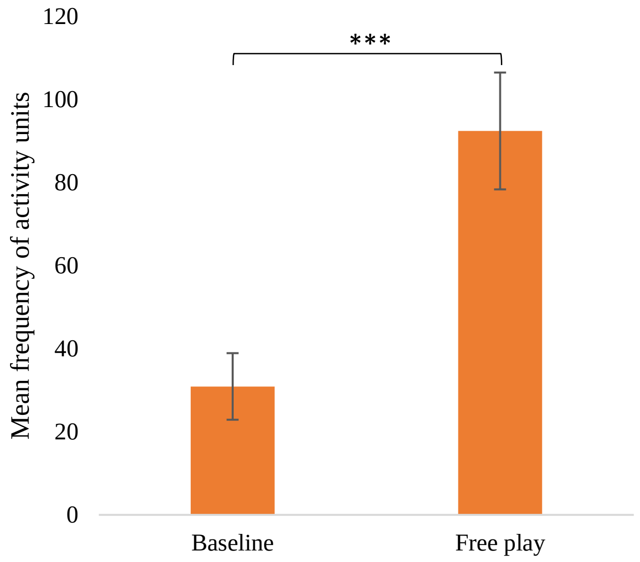


Figure 5.2. Mean frequency of activity units between the baseline and free play conditions in activity units. Error bars represent standard error. *** $p<.001$.

However, there was no significant difference in HRV (as measured by RMSSD) between conditions, $Z=.78, p>.05, r=-.23$ (Figure 5.3), although the large variability in the free play HRV should be noted.

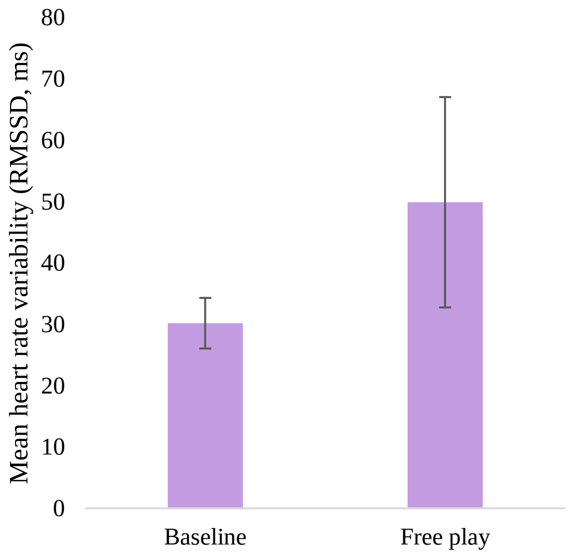


Figure 5.3. Mean heart rate variability represented by Root Mean Square of the Successive Differences (RMSSD) in milliseconds between the baseline and free play conditions. Error bars represent standard error.

To investigate if the level of activity and HRV within the free play condition were related to participant characteristics (i.e. NVIQ, age and autism severity), they were correlated. Although none of these factors were significantly associated with activity or HRV in the free play condition, there were some moderate effect sizes (Table 5.4).

Table 5.4. Spearman's Rho correlations of activity and heart rate variability (as measured using Root Mean Square of the Successive Differences, RMSSD) in the free play condition with non-verbal intelligence quotient score (NVIQ), age in years and autism severity (as measured through Social Communication Questionnaire total score, and Autism Diagnostic Observation Schedule-2 comparison score).

	Activity in free play		**HRV in free play**	
	r_s	*p*	r_s	*p*
NVIQ	.31	.31	-.50	.10
Age (in years)	.17	.58	-.08	.80
Autism severity				
ADOS-2 comparison score	.37	.22	.15	.64
SCQ total score	.05	.86	.12	.72

5.4 Discussion

This is the first study to explore preferences for MSE equipment by autistic children. For 41 autistic children aged 4-12 years, their first unprompted visits to the equipment revealed that the bubble tube was most popular (48%), followed by the touch, sound and light board (37%), the fibre optics (11%) and the tactile board (4%). Considering all data, the order of preference from most to least preferred was the bubble tube; touch, sound and light board; fibre optics; then tactile board.

One reason the bubble tube was preferred may relate to the inclusion of water. There is evidence that water is beneficial for relaxation and wellbeing (e.g. Gearey, Robertson, Anderson, Barros, & Cracknell, 2019). Specifically, watching fish tanks is reported to reduce diastolic blood pressure and anxiety, and increase relaxation (Katcher, Segal, & Beck, 1984; Kidd & Kidd, 1999; Packer & Bond, 2010; Riddick, 1985), explaining why they are often present in waiting rooms. One study has reported improvements in heartrate and blood pressure from observing a fish tank without fish, suggesting the effects are at least partially driven by just the presence of water (Cracknell, White, Pahl, Nichols and Depledge, 2016).

This overall preference for the bubble tube by the present sample of autistic children was not found in a study on ID adults (Thompson & Martin, 1994). As Green et al. (2016) found a difference in sensory profile between their autistic and special educational needs (SEN) groups, there may be specific characteristics of the autistic sensory profile that favour the stimulation provided by the bubble tube. However, none of the equipment preferences were associated with autism severity. Interpretation is primarily limited as the composition of the bubble tube in Thompson and Martin's study is unknown and it may have been very different in size or operation than the one used in the current study, particularly given that the data were collected well over 20 years ago. An additional consideration is that Thompson and Martin had a sample of only six participants, all of whom were adults.

It was found that the shorter time spent sensory seeking, the more visits were made to the tactile board, and less time was spent at the bubble tube. Also, higher parent-reported sensory sensitivity was associated with the less time spent at the bubble tube and more time spent at the tactile board. Both these findings together suggest that children who are hypersensitive to changes in the sensory environment, and produce less sensory seeking behaviours, prefer equipment that offers less sensory stimulation. However, less time spent sensory seeking was also associated with more and longer the visits to the touch, sound and light board, and more visits to the tactile board. Therefore, an alternative but not mutually exclusive explanation is that those who spend less time engaging in sensory seeking behaviours prefer equipment where they can fully control the sensory stimulation they receive.

Participants needed to actively interact with the touch, sound and light board and tactile board for their intended sensory effects to be experienced. Participants with higher NVIQ spent longer at these pieces of equipment and less time with the bubble tube. Individuals with higher visuo-spatial and object manipulation skills may prefer the intellectual stimulation provided by equipment that needs to be manipulated to activate. Although findings from Matson et al. (2004) present another possibility as they found there was an overall preference for visual MSE equipment by their ID participants. Therefore, those in the present sample with lower non-verbal abilities could also be demonstrating this same preference for visual stimuli, as the bubble tube is arguably more visually stimulating than other equipment. However, as level of visual stimulation is difficult to quantify, this explanation is tentative and would need further study.

Finally, it is notable that some variables did not correlate with frequency or durations of visits to equipment, such as autism severity. Further to this, caution should be taken with correlations because of multiple comparisons and replication is necessary.

Limitations

Although this study has been useful in identifying the preferences of autistic children for MSE equipment, coding could only be conducted on four pieces of equipment so preference for the full range of equipment has not been assessed. Further, although the MSE includes the most popular MSE items (see Chapter 3), it did not include all possible types of equipment. This must be taken into account when deciding the best equipment to use for autistic individuals, and likewise by those wanting to choose appropriate equipment to include in a new MSE for autistic children.

A further limitation was that preference was indicated by the first piece of equipment visited, and the frequency and duration of visits, but the participants were not explicitly asked about their preferences. As discussed in Chapter 4, issues of communication or understanding would have limited some participants from responding. However, simple Likert scale of faces from sad to smiling may have supported some participants in indicating their feelings. Future studies would benefit greatly from engaging with the autistic voice to understand their preference for MSE equipment.

Free play was the last condition of this study so the participants may have been fatigued. As the bubble tube requires no manipulation to produce stimulation, preference for it could reflect participant fatigue. Another consideration from these preference findings is that pre-exposure to equipment was not controlled across items, with three pieces having been used in the control study (Chapter 4) but the tactile board being novel (although participants would have seen it previously). Participants lack of preference for the tactile board could reflect IoU (Boulter et al., 2014; Neil et al., 2016), preference for familiarity (e.g. mere exposure effect, Zajonc, 2001), or simply a preference for equipment that they knew how to use.

Finally, the level of experimenter engagement was kept to a minimum in the baseline condition as a control for comparisons with the main experimental manipulation, but engagement was not limited in free play. As such, increased activity in the free play condition could result from increased experimenter engagement. Indeed, although no difference was found in HRV, there was large variability between participants in the free play condition and this finding too could reflect varying physiological responses to increased experimenter engagement. Although this confound limits the interpretations that can be made here, the variability in HRV findings highlights the need for larger samples in future studies measuring HRV so that individualised analyses can be run.

Implications and conclusion

This study is the first to investigate the preferences of autistic children to four commonly used pieces of MSE equipment. It has established preference for MSE equipment with the rank order of preference from most to least being: bubble tube; touch, sound and light board; fibre optics; and tactile board. However, this study has also established that sensory sensitivity, age and NVIQ, but not autism severity, had some effect on preference for equipment. Therefore, practitioners working with autistic children in an MSE and individuals seeking to construct a new MSE should consider their potential users' characteristics when planning sessions and selecting equipment. Practitioners suggested (Chapter 2) that using preferred equipment with autistic pupils may improve motivation and thereby improve outcomes. The empirical evidence of preferences provided by the current study suggest that this would be a fruitful line of future investigation.

Chapter 6: General discussion

6.1 Overview

The aims of the thesis were:

Aim 1: To investigate MSE use specifically for autistic children
Aim 2: To investigate MSEs in a methodologically rigorous way
Aim 3: To investigate the effect of method of use on outcomes within an MSE

These aims have been met in this thesis by investigating the use of MSEs with autistic children (aim 1) through a rigorous sequential mixed methods approach (aim 2). In the first study (Chapter 2), practitioners stated that the MSE was beneficial for autistic children, and that specific methods of MSE use such as the child having sensory control, can improve outcomes. This was then investigated empirically with autistic children (aim 1-3, Chapter 4) and is the largest MSE study on children to date. In addition, the creation of the MSE, along with the development of the novel set of observation measures used in Chapter 4, is described in Chapter 3. Finally, in Chapter 5, further investigation of MSE use with autistic children (aim 1) was conducted by examining the free engagement of these children in an MSE, which was also the first study to date to investigate this.

6.2 Key findings

Theoretical and scientific understanding of the effects of MSE use with autistic children have been advanced through this thesis taking a sequential mixed methods approach. For the first time in this field, this rigorous methodology allowed experts (i.e. practitioners, Chapter 2) to define hypotheses to be investigated (Chapter 4). Indeed, the practitioner-defined hypothesis that providing autistic children with control of the MSE leads to benefits aligned with the broader autism literature including autistic self-report (e.g. Robertson & Simmons, 2015), empirical studies (e.g. Fujino et al., 2019) and autism theory (e.g. Pellicano & Burr, 2012), as well as previous, non-autism specific, MSE theory (e.g. Eijgendaal et al., 2010). When empirically tested it was found that giving autistic children control of the MSE increased their attention, and reduced their RMBs, sensory behaviours, vocalisations and stereotyped/idiosyncratic speech. However, there was no difference in other social communication, enjoyment, anxiety or levels of arousal. This provides some support for the previous MSE theory of control (e.g. Eijgendaal et al., 2010) yet, the mechanistic underpinnings of this effect are less clear as being in control could have enabled behaviour change in the MSE by improving the capacity for sensory needs to be met (e.g. Lane et al., 2010), by improving predictability and thereby reducing IoU (e.g. Boulter et al., 2014; Eijgendaal et al., 2010; Fowler, 2008; Hirstwood & Smith, 1996), or by more general effects of an increased feeling of agency (e.g. Fattore et al., 2009). Of course, a combination of all these could operate at the same time or be more relevant to particular types of children. Although not all outcomes were affected by the child being in control, the pattern of the data is unidirectional, with there being no observable benefit to behaviour from not being in control. To date, this is the best evidence into the effect of MSEs on autistic children which has improved understanding in demonstrating that different methods of use can affect outcomes. Indeed, this thesis not only provides some preliminary evidence for the theoretical underpinnings of MSE use with autistic children, but also it results in further testable hypotheses. For example, in the Chapter 4 study, the participants produced more sensory stimulation for themselves in the control condition suggesting that benefit could have occurred through being in control, more sensory stimulation, or a combination of these. Therefore, testable hypotheses can be extrapolated from these findings (e.g. behaviour changes occur through more sensory stimulation), which if investigated, could serve to further understanding in this field.

In Chapter 2 the practitioners discussed individual differences in MSE use, and evidence for this was found in the free play study reported in Chapter 5, providing further insight into MSE use with autistic children (aim 1). Here it seems that IQ and sensory profile have some influence on preference but there was limited evidence for an effect of age and no effect of autism severity. Those with higher IQs spent longer at the touch, sound and light board, and tactile board, and less time at the bubble tube. There were also interesting associations with sensory profile. Higher sensory sensitivity was associated with less time at the bubble tube and more time at the tactile board. Relatedly, those spending less time engaging in sensory seeking behaviours, visited the tactile board more. However, those engaging in more sensory seeking behaviours, for longer durations, spent more time at the bubble tube. There were, however, more non-significant associations with sensory profile, than significant ones. Indeed, ability levels appear to have the most significant effect on MSE preference. This, and other evidence from Chapter 5, is important not only for those wanting to equip an MSE, but also for practitioners wanting to motivate their autistic pupils with preferred equipment, depending on their individual characteristics and needs.

6.3 Limitations

An in-depth discussion of limitations can be found at the end of each Chapter, but key limitations are highlighted below. There are two main challenges associated with the behavioural MSE study presented in Chapter 4. Firstly, although this study is the largest to date on children's use of an MSE, a larger sample size would have allowed for the investigation of individual differences through subgrouping. For example, with their sample of 72 autistic adolescents, Jones et al. (2009) were able to explore a subgroup with superior frequency discrimination to investigate what characteristics (e.g. intellectual ability) were associated with this exceptional ability. In the context of the present study, a larger sample size would have allowed investigation of who benefitted most or least from having control, and what the characteristics of these samples were. More broadly, investigations into the effect of different methods of MSE use individuals with different behavioural or cognitive profiles is necessary to fully understand how the MSE can be used for maximum benefit. The second challenge associated with this study is that the automatic rate of presentation of sensory changes in the no control condition was not matched to the participants' activation of sensory change in the control condition. This means that it is not possible to determine whether the act of being in control or the resulting increase in sensory stimulation, or both, led to behaviour change. Employing a yoking paradigm whereby the rate of sensory changes produced in the control condition is repeated in the no control condition could support the interpretation of the present findings, although this paradigm introduces issues with order effects.

Issues of data quality led to a large amount of HRV data loss, which is common in HRV studies (see Quintana, Alvares, & Heathers, 2016). Since the present study there have been advancements in 'smart clothing', garments made from materials containing HRV and other physiological monitoring, which are less invasive and easier to attach than traditional monitors (e.g. a single sleeve such as the "AIO smart sleeve" by Komodotec, www.komodotec.com). The use of these garments could increase the number of participants that data can be collected from and should be considered for future studies. A broader issue with HRV is that high arousal can be indicative of both anxiety and excitement, making interpretation of findings difficult. Software is available (e.g. Mangold INTERACT software; Mangold, 2017) that enables video taken of the participant during the data collection to be mapped with the HRV data. This supports observational coding of the interpretation of changes in HRV signal as indicating anxiety or excitement.

Although this thesis contains elements of participatory research, such as the practitioner interviews and the inclusion of lower ability autistic children (see Fletcher-Watson et al., 2019), autistic individuals were not asked to directly report on their experiences of using MSEs, nor were autistic individuals consulted in the design of this research. Conducting research 'with' rather than 'on' autistic individuals is ethically important (Milton & Bracher, 2013) and readdresses the power imbalance of research (Cornwall & Jewkes, 1995). Future research in MSEs should endeavour to take a more participatory approach.

6.4 Implications and future directions

The implications of this work will be presented as recommendations for researchers and then for practitioners. Future directions will also be suggested.

6.4.1 Recommendations for researchers

1. **Innovative research approaches should be used**

As described in Chapter 1, the paucity of methodologically sound research in this field means it is difficult to formulate testable, empirically driven hypotheses. This issue is not insurmountable, as demonstrated by the present thesis in the use of sequential mixed methods methodology. The sequential mixed methods approach allowed for both breadth and depth of insight (see McKim, 2017). Only one other study in this field has used a similar approach, with findings from interview studies (Stephenson & Carter, 2011a, 2011b) informing parts of a survey (Carter and Stephenson, 2012). However, the present study was unique in its translation of the mixed methods findings on MSE use into a behavioural study. The combination of interview and survey data enabled the selection of relevant, ecologically valid outcome measures and provided evidence for a range of possible experimental manipulations. The success and utility of this research approach leads to a strong recommendation for other researchers to consider using this approach. This is especially in cases where previous investigations are limited, and in-depth data gathering is needed to shape direction. However, it is acknowledged that a mixed methods approach is not always appropriate (Hurmerinta-Peltomäki & Nummela, 2006), and it requires more resources, including time, compared to a single method approach.

2. **The selection of MSE equipment should be guided by the research design**

Each piece of MSE equipment has varying properties (e.g. type, modality and level of stimulation), therefore, the requirements of the equipment should be assessed based on the study design *before* they are selected to be included in a study. For example, in the Chapter 4 study equipment needed to be controllable as well as passively provide stimulation. Therefore, the tactile board was not included as it could not provide stimulation without the child's engagment (i.e. it could not be used in the no control condition).

3. **Proper consideration needs to be given to time and funding**

As highlighted in Chapter 3 and the timeline in Appendix C, the installation of an MSE, the testing for an MSE study and study coding can be time consuming. MSE studies are labour intensive and consideration must be given to what is possible in a particular timeframe (e.g. a PhD). Additionally, the installation of the MSE can be costly. Therefore, proper consideration needs to be given to time and funding.

4. **Include participants across the autism spectrum in studies**

Recently, it has been noted in that autistic individuals with lower intellectual ability are under-represented in research (Russell et al., 2019). It is important to include individuals across the whole autistic spectrum in studies, and this is particularly the case with MSE studies, as MSEs are most widely used by those with ID. However, those with lower ability can be more difficult to test as lower intellectual functioning has been associated with more challenging behaviours (Tureck et al., 2014). Therefore, based on experience of including those with lower intellectual ability in the present MSE research, some recommendations are be offered.

Firstly, prior to testing, gather information about the participant to understand their strengths and difficulties (i.e. through school or parent). Try to ascertain the child's ability level by finding out what type of school they are in, how much support they have at school, and their level of expressive language. Also investigate the child's likes and dislikes, as well as any subtle behaviours that indicate they are getting upset, which is especially important if the child is minimally verbal. All this information can support your preparation for the testing session, help to build rapport with the child and avoid escalation of negative behaviours.

Secondly, during testing, consider modifications that can be made if the child is not engaging or is producing some mildly challenging or upset behaviours. These modifications can include switching the order of tasks to one that is more appealing, distraction with a non-task activity, or having a break. Often these small adjustments are enough to settle and support the child, and although it can be a time-consuming approach, it can make the difference between the success and failure of a testing session. Obviously, a child should not continue testing if they are showing significant signs of distress or if they are indicating that they want to stop. One of the challenges of working with children with lower ability, and particularly when communication is minimal, is determining when distress or discomfort is being shown. Understanding the child's behavioural presentation and building rapport can help with this.

6.4.2 Recommendations for practitioners

The studies in this thesis have produced findings of relevance to practitioners and some recommendations for practitioners are provided here. However, these recommendations only relate to MSE use with autistic children aged 4-12, and replication of the findings is necessary. Recommendations 1 and 2, are based on findings from Chapters 2 and 4, and recommendation 3 is based on the findings of Chapter 5.

1. **Providing autistic pupils with control in the MSE can enable some beneficial outcomes**

Providing autistic pupils with control of the sensory environment may be beneficial for practitioners interested in enhancing attention, and reducing RMBs, sensory behaviours, vocalisations and stereotyped/idiosyncratic speech. Benefits are visible within a 15-minute session suggesting that even when time-limited this approach may be useful. Providing control within the MSE is easy to implement by giving the pupil control of the sensory equipment through an iPad, switches or direct engagement through button pressing.

2. Providing autistic pupils with control in the MSE may support teaching and learning

Practitioners may be able to optimise the MSE for teaching and learning by providing pupils with control. For example, if the child is actively operating a piece of sensory equipment then learning about aspects of the physical environment would be possible, for example, colours, textures, on/off, up/down, left/right, and more broadly, cause and effect relationships. It may also be possible to integrate social and emotional learning, such as encouraging interaction with the practitioner or supporting the child in associating different colours with different emotions. Consultation with practitioners would be useful to further investigate the potential of this teaching and learning opportunity.

3. Selecting preferred equipment based on pupils' characteristics

Practitioners may want to select MSE equipment that their pupils particularly like and can use their pupil's ability level and knowledge of their sensory profile to make informed choices. The bubble tube is preferred by pupils with lower IQs and those who engage in high levels of sensory seeking behaviours. The touch, sound and light board and tactile board is preferred by children with higher IQs, with the tactile board also preferred by those with higher levels of sensory sensitivity and more limited sensory seeking.

6.4.3 Future directions

It is possible that the positive effects from providing control of the MSE could extend beyond those with autism to other populations. For example, although there is evidence that autistic individuals have distinct sensory profiles (e.g. Ben-Sasson, Gal, Fluss, Katz-Zetler, & Cermak, 2019), 67% of SEN children have also been found to have atypical sensory profiles (Green et al. 2016). Therefore, for SEN children, having control of the MSE could be beneficial as they could tailor the stimulation to their specific sensory needs. More broadly speaking, the natural interest of being able to control the sensory environment could engage typically developing and disabled individuals of all ages, perhaps enabling benefits. However, as this study only tested autistic children, the effects of providing control of the MSE on other populations is not known. Yet, as MSEs are used with different individuals across different settings (e.g. Ayre, 1998), it is important to establish whether these benefits extend to other populations.

Additionally, the practitioners in Chapter 2 suggested that benefits may continue beyond the MSE session and that this was contingent on the activity that followed (e.g. a quiet activity vs.

playtime). Some literature also suggests that the effects of the MSE may continue beyond the session (e.g. Houghton et al., 1998), although this is not a universal finding (e.g. Chan & Chien, 2017). Therefore, whether benefits exist beyond the MSE and factors that may facilitate this generalisation is an important avenue for future research and would be particularly relevant for practitioners.

The mechanisms of effect of MSEs are under-investigated but knowing how MSEs work is important for them to be used for maximum benefit. The behavioural study (Chapter 4) presented in this thesis provides preliminary evidence that control of the sensory equipment in the MSE can bring benefits for autistic children. However, the underlying mechanisms that make control beneficial are still not understood. Future studies should be designed to investigate the mechanisms of effect of MSEs. As an example, it has been found that colour tints self-selected for visual comfort and clarity that have been overlaid on images of faces can improve emotion intensity judgements in autism (Whitaker, Jones, Wilkins, & Roberson, 2016). The authors suggest that this occurs because the self-selected tints make the visual scene more comfortable. In the control condition of the behavioural MSE study (Chapter 4) participants self-selected colour changes, which could be interpreted as a way of achieving better visual comfort and meeting sensory needs. A future study could ask children to self-select their preferred colour based on visual comfort and then behaviour within the MSE could be measured as the colours change, this would enable exploration of the importance of colour preference in meeting visual sensory needs in the MSE.

As well as enabling benefits for MSE users, Hutchinson and Kewin (1994), and Morrissey and Biella (1987) both describe that MSE use can improve practitioner relaxation and morale. The broader literature has reported on the high level of stress and burnout experienced by special-needs teachers (Cancio et al., 2018; and for review see Fore, Martin, & Bender, 2002), which can lead to ineffective classroom management (Clunies-Ross, Little, & Kienhuis, 2008). Therefore, benefits to practitioners could be an important outcome to consider in the future. Furthermore, the positive outcomes for children might be mediated or moderated by the beneficial effects of the MSE on practitioners, which would be an important avenue to explore.

The practitioners in Chapter 2 described that there are other activities that can produce similar outcomes to MSEs. Indeed, Cuvo, May and Post (2001) reported that time in a playground reduced stereotyped and increased engagement behaviours more than MSE use for their three ID participants. It was beyond the scope of this thesis to investigate the effects of the MSE alongside other activities, but whether similar effects can be achieved in different environments is important to establish. For example, it may be that it is the mere act of being in control (e.g. Fattore et al. 2007) that facilitated benefit for autistic children in the MSE (Chapter 4), rather than benefits being related to any distinct properties of the MSE such as the sensory input.

Finally, most previous observational measures of autistic behaviours and sensory behaviours include the administration of specific tasks that can ‘press’ for certain behaviours. However, the coding scheme developed in this thesis does not have this constraint and allows for the coding of behaviours that emerge during engagement in non-specific activities. The tool is also useful in capturing a wide range of behaviours that are relevant to autism. Therefore, it can be used in future studies not only in this field but in the broader field of autism behavioural research.

6.5 Conclusion

This thesis presents novel research into the efficacy of MSEs for autistic children aged 4-12 years and across a range of intellectual abilities. In Chapter 2, the sequential mixed methods study of practitioners’ beliefs demonstrated that benefits to autistic children were possible from MSE use and that giving the child control can improve outcomes. Another key finding was that the child being in control of sensory equipment within the MSE was believed to facilitate benefits. These findings informed the development of a behavioural coding scheme to measure outcomes for autistic children in the MSE (Chapter 3) and led to a behavioural study (Chapter 4) investigating the effect of being in control of MSE equipment on 41 autistic children, which is the largest study to date on children’s use of an MSE. Finally, data was presented on how the autistic participants chose to engage when they had free access to equipment within the MSE (Chapter 5). The findings of this thesis provide important insights into the effectiveness of MSEs for autistic children, furthering theoretical and scientific understanding, which can support practitioners in using MSEs for maximum benefit.

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Appendix

Appendix A: Practitioner interview schedule (Study 1, Chapter 2)

Demographic data

1. What is your gender?
2. What is your age?
3. What is your job role?
4. How long have you been in this role?
5. How long (in years) have you worked at this school?
6. How often do you use MSE with students?
7. Approximately, how many students with ASD have you worked with in a MSE?

General MSE information

8. What equipment do you have in the MSE? (make sure domain e.g. visual, is obvious)
9. Have you had any training or instruction on how to use the MSE?
10. Do you use the room on a one-to-one basis or in groups?
11. Is the MSE use timetabled?

Use of the MSE and behaviour changes

12. Tell me about ways you use MSE with students with ASD?
    a. Do you have any specific techniques?
    b. Do you use or not use any specific machines?
    c. Why do you use the room in that way?
13. Have you noticed particular students engaging with the room or a specific piece of equipment in the same way every time they use it?
    a. Are some pieces of equipment more popular than others?
    b. Why do you think this is?
14. What are some specific behaviours you have seen students with ASD doing when in MSE?
    a. Were these in response to specific pieces of equipment?
    b. Were these in response to changes in the room (i.e. a certain colour or light intensity)?
15. Have you seen a direct change in the sensory environment, lead to a change in the behaviour of a student with ASD?
    a. Has the student entered the MSE agitated and then calmed down in the MSE?
    b. Has the student entered the MSE calm and then they became agitated in the MSE?

Specific senses and behaviour

We've talked generally about the equipment but now I'd like to hone in on specific senses:

16. For equipment that engages the auditory sense, what sort of effects do they have on the children with ASD?
17. For equipment that engages the visual sense, what sort of effects do they have on the children with ASD?
18. For equipment that engages the tactile sense, what sort of effects do they have on the children with ASD?

Benefits of MSE

19. What are the benefits of the MSE for your students?
    a. Do you consider one benefit the most important?
    b. Is there one piece of equipment that you consider most beneficial?
20. If you see a change in behaviour, how long does it last? Does it last beyond the MSE session?
21. Do you think the MSE affects the student's emotional state or mood?

22. Do you think using the MSE with a pupil affects your relationship with them?
23. Do you see any changes in their social communication?
24. Do you see any changes in repetitive or sensory behaviours?

Drawbacks of MSE

25. We've talked a lot about positives, do you ever experience a negative effect of the MSE on your students?

Behaviour change in ASD compared to non-ASD

26. Have you noticed any differences in the way a student without ASD engages or behaves in the room compared to a student with ASD?
    a. If yes, in what way was the behaviour or engagement with the room different?
    b. Do individuals with different diagnoses like or dislike some pieces of equipment?

Thank you for all of these insights, we area almost at the end now. Before we finish though I would like to ask you more generally about your impression of the MSE:

27. Before we finish, is there anything else you wanted to say or bring up?

Appendix B: Practitioner survey (Study 2, Chapter 2)

Background information

1. How old are you (in years)?
2. What is your gender?
3. What is your current job?
    a. Teacher
    b. Teaching assistant (or special support assistant)
    c. Head teacher
    d. Occupational therapist
    e. Other practitioner, please state your job title in the box below
4. What type of organisation do you work at?
    a. Special-needs school
    b. Mainstream primary school
    c. Mainstream secondary school
    d. Other organisation, please describe the organisation in the box below
5. Please enter the name of the organisation you work at. (*We are asking this so we know how many different organisations have taken part. We will not be using this information in any other way.)*
6. How many years have you been working with pupils with ASD?
7. How many years have you been working with pupils with ASD in MSEs?
8. Are your MSE sessions:
    a. Timetabled
    b. Spontaneous
    c. Both of the above
    d. Other
9. In an average session, how many pupils do you use the MSE with?
    a. More than 6 pupils
    b. 6-4 pupils
    c. 3-2 pupils
    d. 1 pupil
10. Have you had any training on how to use the MSE?
    a. Yes
    b. No
    c. I don't remember
11. If you answered "Yes" to question 10, how useful was the training?
    a. Very useful
    b. Somewhat useful
    c. Not at all useful
    d. I have not had training on MSE use
12. Please indicate whether or not each of the following items are included in the MSE you use most regularly
    a. Bubble tube
    b. Mirror ball (or disco ball)
    c. Colour wheel
    d. Projector
    e. Coloured room lights
    f. Sound wall
    g. Tactile wall display
    h. Aroma diffuser
    i. Music player

j. Fibre optics
k. Mirrors
l. UV lights
m. Sensory toys
n. Infinity panel
o. Touch, sound and light panel
p. Voice changer
q. Tablet technology e.g. iPad

13. How old (in years) is your youngest pupil with ASD who uses the MSE?
14. How old (in years) is your oldest pupil with ASD who uses the MSE?

Your experiences of using an MSE with pupils with ASD

We would like to know about your experiences of using an MSE with your pupils with ASD. To do this we have come up with two lists of statements. Please indicate how much you agree or disagree with the statement by clicking one of the five boxes. We understand that each pupil with ASD is different but for the purposes of this survey please respond to the statements by thinking about the **majority** of your pupils with ASD. You may also work with pupils without ASD. However, please only consider pupils with ASD in your answers. We are interested in your opinion and there are no right or wrong answers.

Response options for each question: "strongly agree", "somewhat agree", "neither agree nor disagree", "somewhat disagree", or "strongly disagree"

For the majority of my pupils with ASD, being in the MSE:

1. Gives them enjoyment
2. Reduces their anxiety
3. Leads to them becoming over-fixated on a piece of equipment
4. Increases challenging behaviours (e.g. hitting, biting, self-harming)
5. Makes them less likely to initiate communication
6. Increases repetitive behaviours (e.g. repetitively fiddling with equipment, hand flapping)
7. Creates or increases positive mood
8. Increases the quality of communication (e.g. eye contact, gesturing, conversation)
9. Helps them to focus and pay attention
10. Leads to them becoming over-stimulated

For your pupils with ASD, to what extent do you agree with the following statements?

1. I have specific goals in mind each time I use the MSE
2. How the MSE should be used is determined by the pupil's needs (e.g. sensory needs, learning needs)
3. The MSE is more beneficial for pupils with ASD than pupils with other special-needs
4. Practitioner experience is essential for effective MSE sessions
5. The most important outcome from the MSE is that the pupil learns
6. The benefits from using the MSE could be achieved using other school activities (e.g. craft time, storytelling)
7. More research is needed into the best ways to use MSEs with autistic pupils
8. The MSE does not always bring benefits
9. Using the MSE with a pupil helps to build your relationship with them
10. I can use the MSE in the same way for each pupil and it will be beneficial
11. The most important outcome from the MSE is that the pupil had fun
12. Benefits of MSE use continue once the pupil has left the MSE

13. The most important factor in a successful MSE session is an active practitioner working with the pupil
14. The pupil's response to the room affects whether or not I use it with them
15. Using the MSE brings benefits because it is motivating for the pupil
16. There are teaching possibilities in the MSE not available in the classroom
17. Using the MSE brings benefits because the pupil can control their environment
18. Training would benefit the way I use the MSE
19. If you have any other comments about using MSEs with pupils with ASD then please write them in the box below.

Appendix C: Timeline of Multi-Sensory Environment (MSE) installation (Chapter 3) and study (Chapter 4)

Note: This timeline only pertains to the creation of the MSE (Chapter 3) and the main MSE study (Chapter 4), it is not indicative of all work undertaken during the PhD (e.g. Chapter 2).

PhD year 1	2015	Nov	Room selection in the Cardiff University Centre for Human Developmental Science, research sponsorship agreement finalised, study designed, and equipment selected
		Dec	
	2016	Jan	
		Feb	
		Mar	
		Apr	
		May	
		Jun	
		Jul	
		Aug	
		Sep	
PhD year 2		Oct	
		Nov	
		Dec	Mike Ayres designing the MSE layout
	2017	Jan	
		Feb	Cardiff University preparing the MSE space: installing a two-way mirror, painting and carpeting
		Mar	
		Apr	
		May	
		Jun	
		Jul	
		Aug	MSE installed, ethical approval granted, and recruitment
		Sep	
PhD year 3		Oct	
		Nov	Testing
		Dec	
	2018	Jan	
		Feb	
		Mar	
		Apr	
		May	
		Jun	
		Jul	
		Aug	
		Sep	Coding: MSE videos, Autism Diagnostic Observation Schedule-2 videos, ability measures, and heart-rate variability data
PhD year 4		Oct	
		Nov	
		Dec	
	2019	Jan	
		Feb	
		Mar	

Appendix D: Coding scheme (Chapter 3)

Observation coding scheme

Throughout coding scheme, the equipment can be referred to using a code:

MB = mirror ball, TSLB = touch, sound and light board, BT = bubble tube, RL = room lights, FO = fibre optics

Summary of coding scheme:

Coding scheme	Coding Type	Software used
Social response, Gesture and Mimicry (Social communication)	Frequency	Elan
Speech – child & experimenter (Social communication)	Frequency and duration	Elan
Rapport	Rating	Excel
Anxiety	Frequency	Elan
Enjoyment	Frequency	Elan
Attention	Rating	Excel
RMB	Frequency and duration	Elan
Sensory	Frequency and duration	Elan
iPad holding (control condition only)	Frequency and duration	Elan
Sensory changes (control condition only)	Frequency	Excel

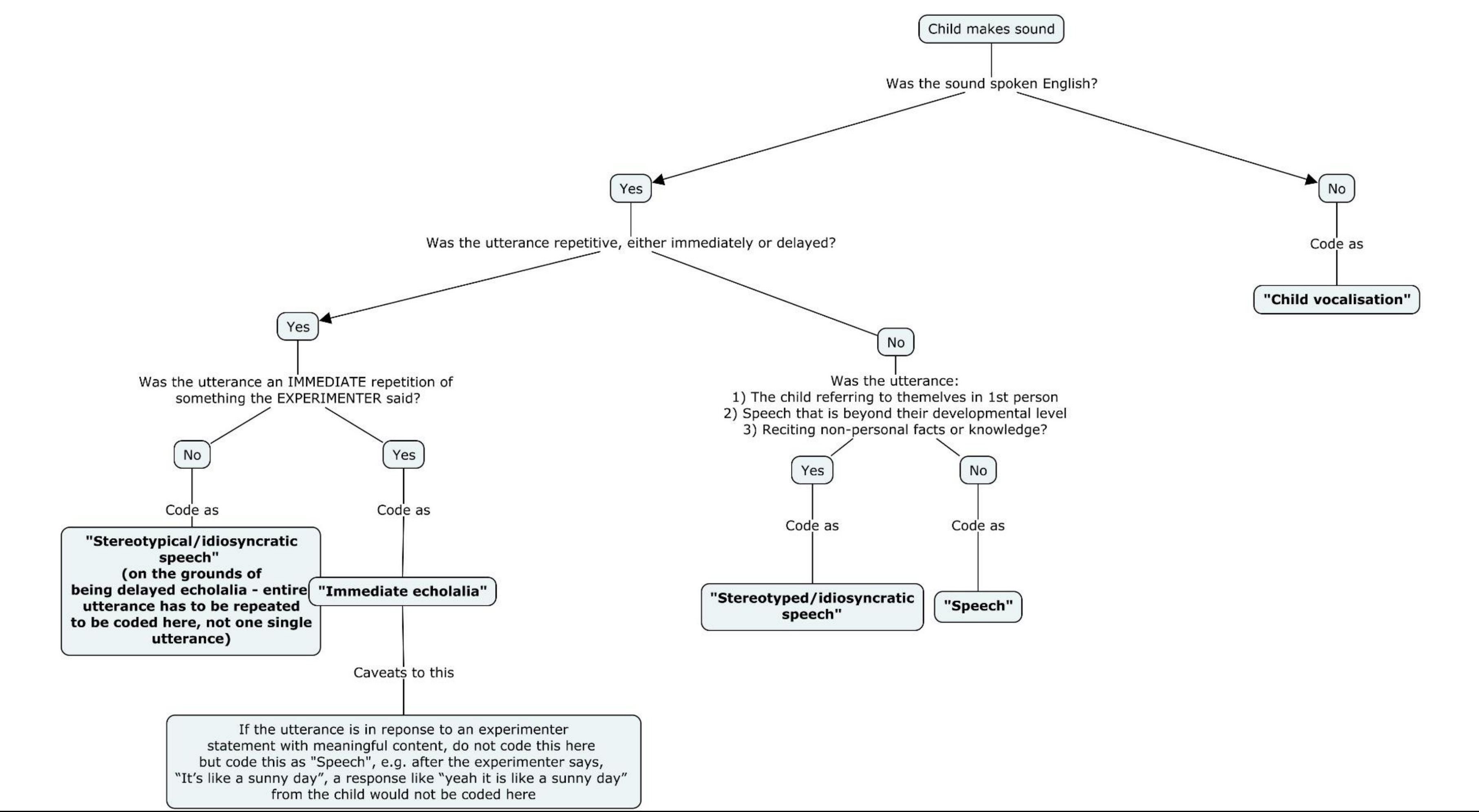
General coding principles:

- Coding for each piece of equipment only (i.e. for 3 minutes of equipment) to avoid coding during variable transition times.
- Always select the camera that has the best shot of the child and code off it – code from only one camera at a time
- Coding begins at the first beep of the experimenter watch on the first piece of equipment. Coding ends on the last beep on the last piece of equipment.

Social Communication *(Frequency and duration)*		
Tiers	**Controlled Vocabulary**	**Definition**
Child speech *(see decision tree)*	Speech (any speech that is not stereotyped/idiosyncratic)	Duration of child speech. Child vocalisations must be recognised as English speech to be coded here, but the content of this speech doesn't have to make sense. Also, for an utterance to be coded here, the articulation does not have to be perfect as some children may have issues with articulation. A good test for coding speech: If it is recognised as spoken English and you could, if necessary, repeat it/type it, it is coded as speech. The whole utterance has to be recognised as English speech to be coded here e.g. "babbl liit cannnlllll star ploiiit" would not be coded here even though "star" is recognised as spoken English because the whole utterance is not recognisable. In contrast, if one word is not recognisable out of an otherwise recognisable utterance, the utterance can be coded here.
	Stereotyped/idiosyncratic speech (including immediate echolalia)	Speech, that is recognised as spoken English, and is: • **Referring to themselves in third person** using their Christian name rather than "I" or "me". The child saying their name followed by unintelligible speech would not be coded here – it would all code as vocalisation. However, the child saying their name followed by intelligible speech, the whole utterance would be coded here. • **Highly repetitive utterances/delayed echolalia** (there may be gaps between repetitive utterances, but each subsequent repetitive utterance is still coded as repetitive). Vocalisations that are unintelligible cannot be coded as echolalia. If it becomes clear that a particular phrase is repetitive, go back to the first use of this phrase and then code every subsequent exact copy here. The **whole utterance has to be echolalic** for it to be coded here, not just one section that is repeated within the utterance e.g. "Teddy went to post-office" then "teddy went to post-office" – this second utterance would be coded here, BUT "Teddy went to post-office" followed by "No sweets at post-office", neither of these would be coded here. Note, stutters are not coded here - the utterance must be a full word that is repeated in order for it be coded here i.e. repetitions of parts of words are not echolalic e.g. "a-a-a-apples are yummy". Note also that repetition of single colour words is **not** coded here because these are likely not to be echolalia, but instead are labelling the colours changing. • **Speech that is beyond their developmental level -** i.e. something that a child wouldn't likely learn at primary school, e.g. mini-professor sounding. o **Neologisms** (newly coined words or expressions) coded here • **Reciting non-personal facts or knowledge** i.e. that do not relate to their own past experience. **Immediate echolalia:** Coded here are the child's **<u>immediate</u>** direct repetitions of the last word, words, statement or series of statements made by the **<u>experimenter</u>**. However, this code should not be used where the child's response to a statement from the experimenter is **<u>meaningful</u>** e.g. after the experimenter says, "It's like a sunny day", a response like "yeah it is like a sunny day" from the child would not be coded here. Note, the utterance must be a full word that is repeated in order for it be coded here i.e. repetitions of parts of words are not echolalic e.g. "a-a-a-apples are yummy". Note, one word colours are coded here if they are an immediate repetition of something the **experimenter** said.

Child vocalisations (non-speech)	N/A	Duration of child vocalisations that cannot be recognised as spoken English. This can include humming, whistling, non-speech sounds, and singing without words (where it is unintelligible) e.g. gasps, making musical notes – a melody. *N.B. It is recognised that the intent of these vocalisations is not identifiable within this code. We are only interested in their frequency and duration.* Note that breathing sounds are not coded here. Laughs and crying sounds are not coded here ('laugh' coded in Enjoyment and 'crying' coded in Anxiety measures), however, if there is question over whether the sound was a laugh or cry, it should be coded as a vocalisation. All one syllable vocalisations/exclamations e.g. oh, humm, um, ee, are coded here. Bodily functions, including breath sounds, are not coded here.

Decision tree for coding speech and vocalisations



Social communication behaviours *(Frequency)* Note: • Gesture: A behaviour must be communicative for it to be coded as a gesture therefore, do not code repetitive behaviours as gestures if they are not communicative • To code a behavioural sequence as two behaviours, the behaviour has to stop and then begin again.	
Showing	Performing an action (e.g. pointing; directing experimenter gaze by looking at the item, then to the experimenter, then back to the item), or saying something (e.g. "look"), that deliberately orients the experimenter to an element of the immediate environment (MSE) with **no identifiable purpose for getting help** (as this could be coded as "Requesting" i.e. questions will not be coded as "showing"). Showing has to be initiated by child not experimenter. Showing can be done with or without vocalisation. The child simply labelling changing colours would not be coded here *unless* the labelling is preceded by a word to direct the examiner (e.g. "look, blue"), or the child looks at the experimenter whilst saying the colour. Be aware when coding this that the child may display a gesture (e.g. pointing) when showing, and the gesture must also be coded separately within the "Gesture" tiers. Showing cannot be coded when the show is directly related to the physical iPad (e.g. showing the experimenter something about the handle would not be coded), however, the iPad functions (e.g. changing colours on the equipment) could be coded if they meet the criteria for showing.
Requesting	A conventional indication – through gesture, eye contact, vocalisation, facial expression or other means – of the child's **desire** for a particular **action or object**. This does not include a general desire to be held, or requests to leave the room (as this could be coded in the Anxiety scale). To code as "requesting" there needs to be **coordinated eye gaze and point (which can include a point that touches object)** to a piece of equipment or another thing in the room (non-verbal), or **a verbal request**. If the child simply says "bubbles" while at the TSLB, this cannot be coded as requesting. However, if they say something indicating want, it can be coded here e.g. "want bubbles", "bubbles now", "bubbles on". Be aware when coding this that the child may display a gesture (e.g. pointing) when requesting, and the gesture must also be coded separately within the "Gesture" tiers. Anything relating to a desire of the child for a particular action or object should be coded here even if it comes across through intonation or other means that the child is making a demand with negative affect. Requests can also be coded when they are made by the child (and fit the criteria above) and are part of a game e.g. turn taking to press buttons on TSLB.
Offering information	The child spontaneously, and appropriately**, offers personal information (e.g. own thoughts, feelings or experiences)**. It does not have to occur in a particular context or as part of a sustained interaction. All offering of information is coded here, even if it appears to be part of the child's special interests, but it must constitute as personal information (e.g. listing types of dinosaurs would not be coded here but talking about a trip to the National History museum where they saw dinosaurs, would be coded here). The information that the child offers has to be understood by the coder to be coded here i.e. mumbles that sound like they could be offering information cannot be coded.
Asks for information	The child spontaneously expresses interest in **the <u>experimenter's</u> ideas, experiences or reactions**. This should not be part of a preoccupation. Exclude information requests not related to the experimenter e.g. exclude questions about the MSE. If an utterance is not coded here on the grounds that it is considered part of the child's preoccupation, then make a note of the timestamp.
Shared enjoyment	The demonstration of **<u>directed</u>** pleasure/enjoyment (e.g. smiling, laughing or verbally stating enjoyment – make sure to check all camera angles for these) **with experimenter** (i.e. the experimenter is also showing pleasure/enjoyment, that is, the experimenter has to be smiling, laughing or verbally stating enjoyment too) that is appropriate to the context e.g. both the child and experimenter are

	laughing. Only code shared enjoyment if there is some indication that the child is **sharing** enjoyment with the experimenter. The child and experimenter both laughing at the same time, does not necessarily mean that the child is sharing enjoyment.
Gestures*	
Conventional	An action that is part of a learned, shared, symbolic system e.g. clapping for well done (clapping may occur in an RMB context – for it to be coded as a gesture it has to be *within a social context*, this may be indicated by the child looking at the experimenter while clapping for example), waving for hello, shrugging, nodding.
Informational	An action that provides information about something being described e.g. "the fish was this big" holding out arms. Informational gestures relating to the MSE can be coded here e.g. "the bubble was this big", whilst holding out arms, also saying "bubbly" and then moving hands and fingers in an upward direction (thereby demonstrating that the bubbles are floating upwards)
Emphatic/beats	An action that accompanies speech which serves to stress a word or point e.g. beats accompanying speech
Deictic	A point (distal or proximal) that refers to something around the child that the child wants to draw attention to. Drawing attention to will manifest as a vocalisation (e.g. "look") or directing gaze to something. A deictic gesture would not be coded here if the point is activating the TSLB or iPad.
Mimicry	
Full mimic	The child copies an action performed by the experimenter that exactly reflects all elements of the performed action (i.e. a direct and perfect copy). It doesn't matter if the action is done in a different location to the experimenter.
Partial mimic	The child copies only part of the action performed by the experimenter such that it is obvious they are doing a similar action but they don't complete it exactly as the experimenter did. It doesn't matter if the action is done in a different location to the experimenter.
Rapport	
Rapport	The code for this item is a summary rating that reflects the examiner's overall judgement of the rapport or comfort level established with the child during the sensory room session. For each condition, assign a rapport rating from 0-3: 0= Comfortable interaction between the child and examiner that is appropriate to the sensory room context 1= Interaction sometimes comfortable, but not sustained e.g. sometimes feels awkward or stilted, or the child's behaviour seems mechanical or slightly inappropriate 2= One-sided or unusual interaction resulting in a consistently mildly uncomfortable session 3= The child shows minimal regard for the examiner and/or the observation is markedly difficult or uncomfortable for a significant portion of time.

*The only change from ADOS was not including "instrumental" as it is not clear what the definition of this is in the ADOS or wider literature. See Fusaro et al. (2011) as a justification for including "shrugging" and "nodding" as a conventional gesture.

Anxiety
(Frequency)

Tiers	Definition
Whine or whimper[1]	Child vocalises and it *sounds like a cry* without tears being visible – there must be indication of distress. Distress can be demonstrated through speech or vocalisations (negatively valanced) amidst the whine or whimper, facial expressions that are negatively valanced (e.g. frown), or through body language (e.g. slumping the shoulders). Whine or whimpers will usually be high pitched. The whole duration of the vocalisation must be whine or whimper for it to be coded here. Whine or whimper cannot be coded at the same time as irritable. Also, if whine or whimper becomes an irritable behaviour, it is just coded as irritability and not whine/whimper.
Stutter[1]	Child speaks but involuntarily stumbles/pauses over words
Trembling/shaking body or voice[1 2 3 4 5 6]	Child is trembling or shaking (may look like shivering) or they have a trembling voice when speaking
Jumpiness[2]	Child appears jumpy e.g. the whole body, head or torso and arms move quickly backwards in a jerky motion. Note this code does not include actual jumping (this could be coded in RMB if it is repetitive)
Body contortions or rigid posture[1 6]	Child twists or holds their body in an unusual way (i.e. their body positioning looks awkward, not normal, uncomfortable or the body position is preventing them from doing the task) or has rigid posture (e.g. pin themselves against something (e.g. wall or BT) with their back straight and heels against the wall, or very close. The legs should be close together, although they don't have to touch).
Physical complaint[1 4 5 6]	Child says he or she has a headache, stomach-ache, or has to go to the bathroom – this code does not include a physical complaint after the child has hurt themselves
Desire to leave[1 6]	Child says he or she wants to leave the testing room or makes excuses about why he or she must leave; desire or "need" to leave must be explicit. Can also be non-verbal e.g. trying to open door
Expression of fear or worry[1 2]	Child complains about being afraid of or worried about something; must use the word "afraid," "scared," "worried," or a synonym, or child gives a clear non-verbal signal of fear or worry. This includes worried or fearful facial expressions or body language directed toward the examiner.
Cry[1 2 6]	Produces tears
Irritable[6 7 8 9 10]	The child displays anger or frustration. This could be displayed verbally/vocally (e.g. "go away", "no", "don't disturb me", shouting) or behaviourally (e.g. stamping feet (not jumping as this would be coded in RMB), violence, folding arms, turning away from the experimenter, hiding hands when experimenter reaches to take their hand, pushing past experimenter, hitting, slapping). These verbalisations or behaviours are inappropriate to the situation. N.B. Importantly, irritability cannot be coded if there is just a **vocalisation** that sounds irritable, that vocalisation must be accompanied by a behaviour. However, irritability can be coded from just a **behaviour**.

Measures or papers that the anxiety codes were drawn from (but not necessarily the definition):

[1] Preschool Observation Scale of Anxiety (POSA; Glennon et al 1978)
[2] Autism Diagnostic Observation Schedule 2 (ADOS-2; Lord et al 2012)
[3] Anxiety Scale for Children- ASD (ASC-ASD, Rodgers et al 2016)
[4] Screen for Child Anxiety Related Disorders (SCARED; Birmaher et al 1999)

[5] Spence Children's Anxiety Scale-Parent (SCAS; Spence et al 2000)
[6] Paediatric Anxiety Rating Scale (PARS; Riddle et al 1997)
[7] Dougherty et al (2015)
[8] Dougherty et al (2013)
[9] Stringaris (2011)
[10] Valle Krieger et al (2013)

Global RATINGS:

Coded on Excel:

1) At the end of each piece of equipment, refer to the coding definitions below 0-2 (NOT the behaviours coded in ELAN) and assign an anxiety rating that reflects the overall level of anxiety
2) At the end of the condition (control, no control, or free play), look at the global codes, and assign a session anxiety rating that reflects the overall level of anxiety

- LOW = 0 = No anxious behaviour or mild and occasional presentation
- MED = 1 = Anxious behaviours that are mild but persistent, or marked anxiety behaviours that are occasional
- HIGH = 2 = Marked anxiety behaviours that are persistent

Enjoyment
(Frequency)

Note: There must be a period of time, where no enjoyment is shown, between the off-set of one enjoyment behaviour and the on-set of another enjoyment behaviour to be coded as two separate behaviours

Tiers	**Definition**
Smiling	The corners of the child's mouth are turned up, cheeks are raised, and the front teeth can be exposed± (N.B. the eyes should not be considered as they are typically too hard to see). To code a smile the whole face must be visible. A smile can be any duration but for it to be coded as two smiles, there has to be a break in the middle of the smiles where no smile is present. If a smile is suspected but it is not obvious, look frame by frame. When in doubt, do not code it.
Laughing	The child can smile (as above, although this is not a requirement of coding a laugh), and this is coupled with a sound that is not one long sound but is broken up by very small breath/s. A laugh can be coded from audio alone, the smile does not have to be visible. However, the audio must be positively valanced. If it is not, then it should be coded under "Anxiety: trembling voice". Audio that sounds like a chuckle (typically shorter and less intense than a laugh) can also be coded here. N.B. As this code already encompasses a smile therefore, smiles cannot be coded concurrently with laughing. A smile and laugh can only be coded as separate **if** the smile precedes or comes after/continues after a laugh has finished.

Verbal expressions of enjoyment	The child verbally states that they are: having fun, enjoying themselves, loving it, or saying it's great, or some other clear indication of a positive experience (e.g. "my favourite is…(something related to the sensory room)", "happy", however, NOT including "I prefer…"). However, the verbalisation has to be positively valanced and a commonly accepted expression of enjoyment to be coded here (e.g. "wow", "woah"). If a smile is present during this code then it can be coded concurrently.
Integrated singing and dancing[1 2 3]	Rhythmic body movement (e.g. dancing) accompanied by musical vocalisations that have a positive intonation (e.g. singing, humming). Dancing involves at least the upper body (child can be seated). For example, the child hums a tune and moves their body rhythmically to the tune. Note: the body movement has to be accompanied by musical vocalisations (not including tapping) to be coded here*. The musical vocalisations can be mimicked, and if accompanied by dancing then it should be coded here (e.g. mimicking a sequence of notes from TSLB, and moving in the same rhythm).

Definition adapted from:
[1] Murcia et al. (2009)
[2] Blasing et al. (2012)
[3] Sevdalis et al. (2011)
[±] Dictionary entries for 'smile' including Cambridge dictionary
* This specification is to prevent interpreting ambiguous body movement as dancing. Murcia et al (2010) specifies that for movement to be classed as dancing it has to be performed with rhythmical stimuli. Sevdalis et al (2011) doesn't state either way – they only specify it is the rhythmical patterning of body movements. Only Blasing et al (2012) suggests it can be with or without music – yet, this does not mention rhythmical stimuli i.e. without music could presuppose the presence of rhythmical stimuli that is not music per se.

Global rating:

1) After each piece of equipment assign a global rating using the definitions below NOT amount of ELAN codes
2) At the end of the whole condition, assign a global rating using the definitions below NOT amount of ELAN codes

- LOW = 0 = No or mild and occasional enjoyment is shown
- MED = 1 = Enjoyment behaviours that are mild but persistent, or marked enjoyment behaviours that are occasional
- HIGH = 2 = Marked enjoyment behaviours that are persistent – such that you can say the child had fun (must be unambiguous enjoyment)

Attention

(Control and No Control)

TSLB, BT and FO only (not MB nor RL)

Coded on excel:

1) **Global rating at each of the three pieces of equipment: TSLB, BT and FO**

Definition of "on-task" = During the MSE session the child is encouraged to pay attention to each piece of equipment for three minutes as directed by the experimenter. This can include touching, looking at or using the equipment or the iPad (control only).

Definition of "off-task" = Being off-task includes the child not touching or looking (directly or indirectly) at the equipment (including iPad) that they encouraged to pay attention to. Being off-task may include physically turning away or being physically present but persistently looking away from the equipment.

Take care over the looking direction as the child may not be looking at the equipment itself but instead, for example, be looking at the BT indirectly in the mirror – this would not count as off-task.

Distractibility rating for the whole time spent at each of the three pieces of equipment: TSLB, BT & FO:

- LOW = 0 = No distraction - The child remains on-task (i.e. at the necessary piece of equipment) throughout the 3-minutes
- MED = 1 = Some distraction - The child shows distraction at times but spends only a small amount of time off-task (i.e. more time is spent on-task than off-task)
- HIGH = 2 = High distraction - The child shows distraction consistently and spends a large amount of time off-task (i.e. more time is spent off-task than on-task)

Repetitive Motor Behaviours

(*Frequency and duration)*

Repetitive behaviour = A behaviour (e.g. tapping foot) that is repeated **successively** with no intervening behavioural event. If the behaviour ends, there is a pause and then begins again, these would be coded as 2 separate repetitive behaviours. For example, a child may tap 5 times with their foot, then talk to the experimenter or there is a period of inactivity, then they tap again for 5 times, these would be coded as 2 separate events.

Note:

- A pause is defined as the behaviour completely stopping and the child reverting to a pre-behaviour position before starting again e.g. flapping, hands come down, flapping again ➔ 2 RMBs with an intervening pause
- Behaviours should only be coded as RMB if they serve no purpose of activating a piece of equipment including TSLB, iPad, or box next to equipment that changes colour.

- For example, flapping arms repetitively serves no obvious function within the MSE and therefore WOULD be coded as an RMB, BUT pressing the buttons on the TSLB repetitively serves the function of activating the light therefore, this would not be coded as RMB. This is the case in the No Control condition as well, as the child could be trying to activate the TSLB as they did before in the control condition (even though now, it cannot be activated).
    - Tapping on the iPad or TSLB should not be coded as RMBs for either condition.
    - Also, touching the boxes that change the colour for the equipment would not be coded unless the touch is unusual (coded as ST) or repetitive in one location on the box (coded as RMB).
- Tapping the experimenter to get attention or request something should **not** be coded here
- **If the experimenter displays repetitive action (e.g. during a press) and the child repeats it, it should not be coded here as it would be coded as a mimic**
- Only **individual** repetitive behaviours can be coded (e.g. flapping), sequences of behaviours that aren't individually repetitive but are repetitive as a sequence cannot be coded here (e.g. head turn, run, touch TSLB then repeat again wouldn't be coded).

Tiers	**Definition**
Whole body	Child rocks or sways body repetitively *e.g. sitting at the bubble tube rocking the torso backwards and forwards* ***more than once*** *(However, one forward and back motion would not constitute repetitive)*
Hand/finger/foot	Child flaps (arms or hands are moved quickly in a to-and-fro manner: typically, it's the <u>hands</u> that are moved backwards and forwards multiple times), claps or shakes hands or arms, or wiggles or flicks fingers or feet (or foot), taps item or themselves (not including tapping the experimenter for attention, and not including tapping the iPad or TSLB) repetitively, *e.g. child is lying on their front changing the colours of the room lights and is tapping their foot on the floor with more than one tap.* N.B. stroking cannot be coded as RMB, it would be coded under sensory. This is mainly because stroking has a very high sensory element.
Locomotion	Child turns in circles, whirls, jumps, bounces or runs repetitively *e.g. the child jumps on the spot, N.B. even if while jumping they don't come off the floor very high, their movement can be characterised as moving up and down repetitively so is coded here.* Note: If the child runs (out), then runs (back), only once this WOULD still be coded as RMB as the run is repeated. The direction of the run is irrelevant.

Sensory behaviours

(Frequency and duration)

The behaviour being coded here should be reflecting a sensory experience.

Note:

- The below list of behaviours is an exhaustive list. One of the exact behaviours listed in the "Behaviour" box below must be present for a behaviour to be coded as sensory. That is, a coder cannot decide that a random behaviour has a sensory quality and code it here.
- If a behaviour is sensory but meets the criteria for RMB (that is, "A behaviour that is repeated **successively** with no intervening behavioural event") then it **should not** be coded here and should be coded in RMB instead.

- However, if two distinct behaviours occur concurrently, one is sensory and other is RMB **then these can be both coded** in their respective tiers. However, ONE behaviour CANNOT be coded as both sensory and RMB.

- If there is a behaviour/s that is in a direct response to external noise (e.g. building work sounds), then these should NOT be coded
- If two sensory behaviours are done at the same time, code them both (e.g. looking closely at TSLB light and stroking the TSLB at the same time), these should be coded as two separate behaviours (e.g. Seeking Visual for looking at the light and Seeking Tactile for stroking the TSLB)
- No sensory behaviours related to the iPad itself can be coded (this is because the iPad is not present in the no control condition)
- If a behaviour is prolonged (this can include child pausing), as long as the modality or nature (i.e. defensive or seeking) doesn't change, it should be coded as one long behaviour
- Looks to the mirror whilst at the BT or adjacent bench can be coded as seeking visual (SV) if they meet the criteria for SV outlined below. If the child is at a piece of equipment, other than the BT, and they seem to be looking from a distance at themselves or the object in the mirrors, this should NOT be coded as seeking visual (SV), even if their looking is prolonged or at an unusual angle. However, looks at the mirror from a distance (i.e. from other pieces of equipment) should not be coded due to issues with reliability of interpreting the direction of gaze.
- "Prolonged" is defined as more than 10 seconds
- The child producing vocalisations is not included here as the reasons behind these vocalisations is not readily discernible, and generally vocalisations have far more possible origins than other sensory behaviours

Coding categories:

- Each behaviour should be coded by; (1) whether it was defensive or seeking in nature, and (2) modality
  - Defensive = This is where the child does a behaviour to 'defend' themselves - they retract from or move away from the stimuli/stimulation. These behaviours are considered "exaggerated responses to the stimuli presented" (see Baranek et al, 2017, 2018) e.g. putting hands over ears
  - Seeking = This is where the child does a behaviour to 'seek' more stimulation – they try to get more from or out of the stimuli. The behaviour "serves to intensify, repeat or reinforce sensory experience" (Baranek et al 2018, p.30) e.g. getting very close to the light on the TSLB

Tiers	**Behaviour**
Defensive Visual - DV	Aversive reaction to visual stimuli [3] • Covering eyes with hands[1 2] or beanbag/bench • Is startled (e.g. pain/discomfort facial expression) after visual stimulation[1] • Rubs eyes to light[1] • Averting gaze away from the light omitted from the equipment – may be noticeable as a head turn or moving the head backwards • Moving away rapidly from object after a visual stimuli[1] - must be an immediate pull back and the movement must be rapid/abrupt e.g. tilting head backwards rapidly immediately after looking at BT. It would not be coded here if the child simply pulls their head back in a slow manner[1 2]

	N.B. However, to code DV, the child cannot continue creating the visual stimuli whilst performing defensive behaviour, e.g. If the child pulls their head back but still presses TSLB button then this would not be coded as DV. This is because if the child continues to create the visual stimuli then their looking away is not defensive but has another purpose.
Defensive Auditory - DA	Aversive reaction to auditory stimuli[3] • Putting hands (or hand) over, or finger/s in, ears[1 3 5] This can also include the child bringing their shoulders up to cover their ears or using a beanbag to cover their ears. • Is startled (e.g. pain/discomfort facial expression) after auditory stimulation[1 2] • Moving away rapidly from object after an auditory stimuli[1] o See description in DV for what this could look like
Defensive Tactile - DT	Aversive reaction to tactile stimuli [2 3] • Moving away rapidly from object in a rapid/abrupt fashion after touching it[1 2] o See description in DV for what this could look like • Is startled (e.g. pain/discomfort facial expression) after tactile stimulation[1 2] • Shrugging shoulder after it is touched by experimenter[1] • Wiping hands/arms immediately after having touched something
Seeking Visual - SV	• Fixates on visual stimuli (intense peering, visual inspection) – this would be noticeable as looking for a prolonged period at an object, themselves or the experimenter [2 4] • Unusual visual examination - looking/peering at anything from a strange angle ('strange' defined here as not the typical way someone would look at something, this would be noticeable as the child would tilt their head to an angle away from upright and hold it there while they look at the equipment) [3 4]. N.B. Head tilt at equipment that is at the child's eye height is coded as SV – the child doesn't need to tilt to see it. • Putting face very close to a light or an object *Shortcut to remember: Looking that is prolonged in duration, at an unusual angle or at an unusual proximity*
Seeking Auditory - SA	• Repeatedly seeks out/fascinated by sounds [2 3 4] - putting an ear close to item ("close" = closer proximity than usual to the speaker or equipment that gives sound), this can include putting ear to an item that may not be obviously auditory e.g. low hum of BT (Cannot include production of own sounds as we would be making a sweeping value judgement about the purpose of the vocalisation- vocalisations can be used for more purposes than other sensory behaviours)
Seeking Tactile - ST	Seeks opportunity to feel textures in an unusual/specific manner or for extended periods[2 3] • Rubbing hands, or any other body part, on an element of the equipment, stroking it, or touching it **in an unusual/specific manner**[3] e.g. with the back of the hand. N.B. Any body part can be used for this code e.g. cheek or foot. *This behaviour must not be repetitive to be coded here (if it is repetitive it should be coded as RMB).* This code should not be used for tapping behaviours that are RMBs. N.B. *Unusual* is defined in this context as any touching behaviour that **does not involve the palm of the hand**. The only exception to this being Stroking (specific). If the child is at the FO, and they wrap it round a body part, ST is only coded for the duration that the seeking action is taking place (i.e. manoeuvring the FO into position), not when they have stopped and the FO just happens to be touching the body part still.

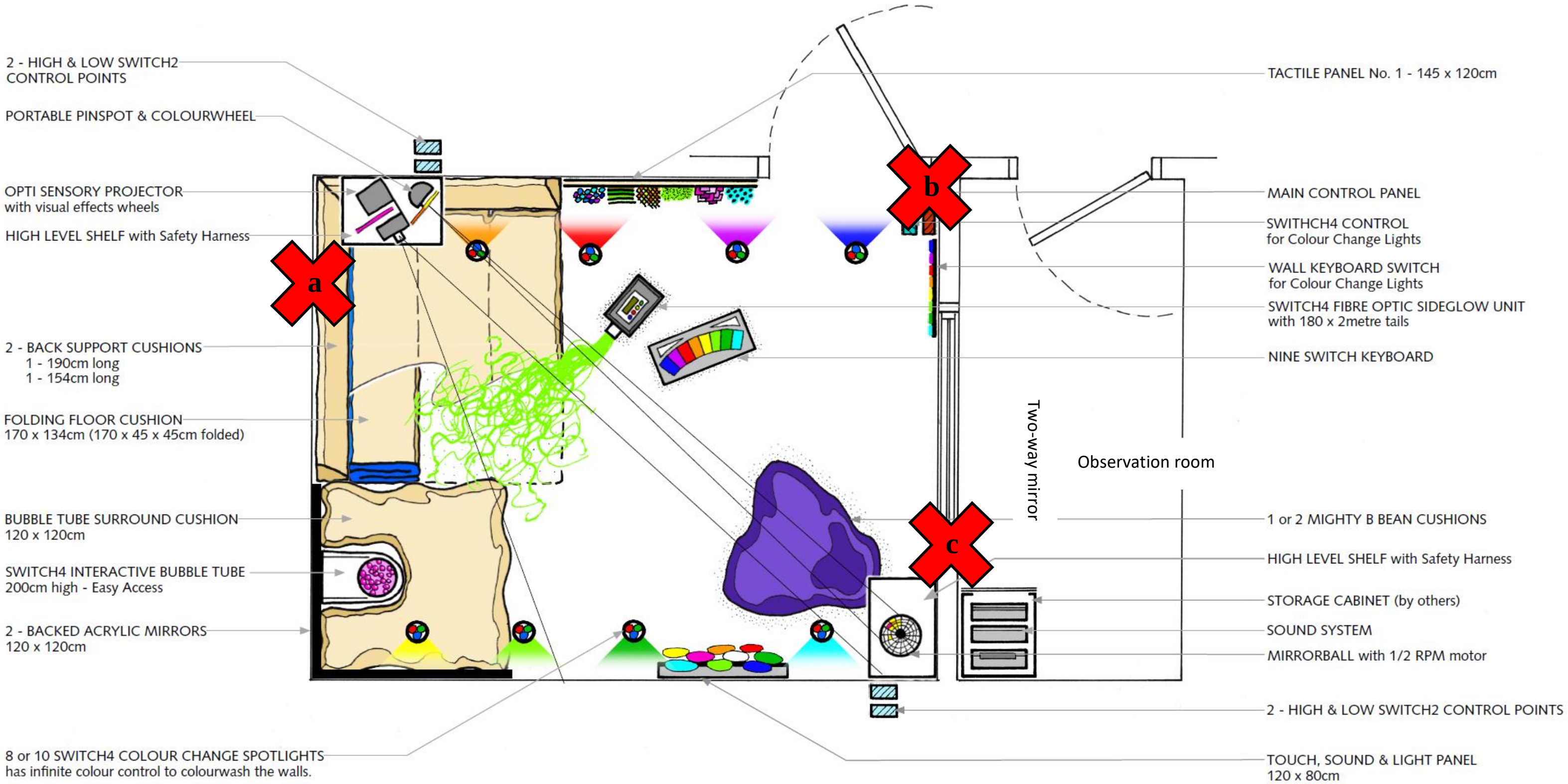
	• Rolling items between fingers • Seeking physical contact with the experimenter e.g. the child, even if they are at the equipment they are meant to be, tries to hug the experimenter. This seeking needs to be unusual in type or seems prolonged in nature i.e. child touching experimenter briefly as they move past would not be coded, however, holding onto their shoulder would. • Licking [4], biting[3] – putting objects in the mouth IMPORTANT: Cupping hand/s around ear to enhance auditory stimulation and cupping hand/s around eyes to enhance visual stimulation would NOT code as tactile (even though hands may be slightly touching an object/face) because any tactile stimulation is considered a secondary consequence of trying to enhance visual or auditory stimulation

Measures or papers that sensory codes were drawn from:
[1] Sensory Processing Assessment (SPA, Baranek, 1999)
[2] Sensory Assessment of Neurodevelopmental Disorders (SAND, Siper et al., 2017)
[3] Autism Diagnostic Observation Schedule (ADOS-2, Lord et al., 2012)
[4] Baranek et al. (2018)
[5] Lane et al. (2010)
Items were also generally informed by the Glasgow Sensory Questionnaire (GSQ, Robertson & Simmons, 2013), Sensory Experiences Questionnaire (SEQ, Baranek et al., 2006) and Sensory Profile (SP, Dunn, 1999)

Other coding	
Item	**Description**
Sensory changes (Excel)	Frequency count the number of sensory changes in a session (control only) - Excel
Coding notes	Noting if there are any issues with coding, e.g. whether a behaviour could have coded onto two items
iPad holding (control condition only) (ELAN)	Duration of time participant is holding the iPad in their hands in the control condition. N.B. This is the time that the CHILD is holding the iPad in their hands and therefore, unable to engage in RMB or with the equipment. The child has to be bearing the weight of the iPad in their hands for it to be coded here i.e. if they were to remove their hands from the iPad, it would fall). If the iPad is on the lap, equipment, floor, bean bag or experimenter is holding it, it is not coded.
Experimenter speech	Duration of experimenter speech

Appendix E: Schematic of MSE including camera positioning (Chapter 4)

Schematic of the MSE at CUCHDS with camera placement marked with red crosses; a) above the bench-seat capturing predominantly the tactile board and fibre optics, b) above the door frame capturing predominantly the bench seat, bubble tube and touch, sound and light board, c) above the two-way mirror capturing predominantly a closer view of the bubble tube and touch, sound and light board. N.B. as the mirror ball and LED room lights affected the whole room, these were captured on multiple angles. Used with permission from Mike Ayres.



Appendix F: Frequency of behaviours in the behavioural MSE study (Chapter 4)

Table A1. All behaviours performed across both conditions.

Behaviour category	Individual behaviours	Total number across conditions	Average per participant	SD	Range	Percentage of category total
Social		**1321**	**32.22**	**42.68**	**230**	
	Showing	740	18.05	27.57	137	56
	Requesting	93	2.27	3.46	15	7
	Offering information	369	9.00	15.80	83	28
	Asking for information	43	1.05	2.40	9	3
	Shared enjoyment	76	1.85	2.38	9	6
Gesture		**471**	**11.49**	**13.51**	**55**	
	Conventional	69	1.68	2.35	9	15
	Informational	63	1.54	2.95	13	13
	Emphatic	3	0.07	0.26	1	1
	Deictic	336	8.20	9.89	41	71
Mimic		**194**	**4.73**	**3.07**	**12**	
	Full mimic	97	2.37	2.28	7	50
	Partial mimic	97	2.37	1.69	6	50
RMB		**1334**	**32.54**	**20.26**	**87**	
	Whole body	111	2.71	3.52	14	8
	Hand/finger/foot	907	22.12	14.17	67	68
	Locomotion	316	7.71	11.65	61	24
Sensory		**3229**	**78.76**	**31.82**	**147**	
	Seeking	3021	73.68	32.36	146	94
	Defensive	208	5.07	8.37	47	6
Anxiety		**506**	**12.34**	**11.45**	**54**	
	Whine/whimper	40	0.98	2.80	15	8
	Stutter	63	1.54	4.15	19	12
	Trembling body	17	0.41	1.05	6	3
	Jumpiness	17	0.41	1.07	6	3
	Body contortions	139	3.39	4.57	20	27
	Physical complaint	1	0.02	0.16	1	0
	Desire to leave	18	0.44	0.84	3	4
	Expression of worry	24	0.59	1.00	3	5
	Cry	0	0.00	0.00	0	0
	Irritability	187	4.56	7.65	40	37
Enjoyment		**1277**	**31.15**	**25.87**	**125**	
	Smile	569	13.88	10.75	48	45
	Laughing	428	10.44	13.83	63	34
	Verbal expression of enjoyment	240	5.85	9.69	50	19
	Integrated singing and dancing	40	0.98	1.73	8	3
Speech‡		**5712**	**139.32**	**114.04**	**448**	
	Child speech	4603	112.27	100.21	384	81

	Child stereotyped/idiosyncratic speech	1109	27.05	22.22	101	19
Vocalisations*		4701	114.66	92.16	478	100

‡ Speech total comprises of child speech and child stereotypic/idiosyncratic speech, it does not include vocalisations

* Vocalisations are not included in the overall speech figure as vocalisations are not 'speech'. I acknowledge that this measure contains not only potentially communicative vocalisations, but also sensory vocalisations, as the two cannot be reliably differentiated.

N.B. Attention and rapport are not included here as they are on global rating scales

Appendix G: Means of individual social communication and interaction codes (Chapter 4)

Table A2. Individual behaviours in the control condition comprising the social behaviours, gestures, and mimicry variables

	Mean	Std. Deviation	Median	Range
Social behaviours				
Showing	8.83	12.73	5	57
Requesting	1.00	1.75	0	6
Offering information	4.24	8.17	1	42
Asking for information	0.59	1.72	0	8
Shared enjoyment	1.02	1.74	0	8
Gesture				
Conventional	0.68	1.08	0	4
Informational	0.61	1.12	0	5
Emphatic	0.07	0.26	0	1
Deictic	3.59	5.44	2	30
Mimicry				
Full mimic	0.98	1.17	1	4
Partial mimic	1.12	1.05	1	4

Table A3. Individual behaviours in the no control condition comprising the social behaviours, gestures, and mimicry variables

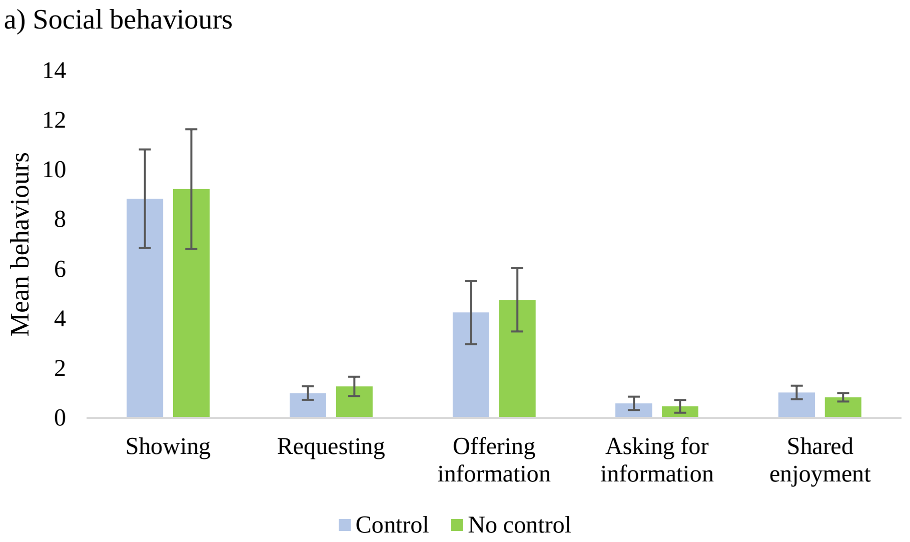
	Mean	Std. Deviation	Median	Range
Social behaviours				
Showing	9.22	15.42	3	80
Requesting	1.27	2.49	0	10
Offering information	4.76	8.17	0	41
Asking for information	0.46	1.64	0	9
Shared enjoyment	0.83	1.09	0	4
Gesture				
Conventional	1.00	2.00	0	8
Informational	0.93	2.35	0	12
Emphatic	0.00	0.00	0	0
Deictic	4.61	5.73	2	19
Mimicry				
Full mimic	1.39	1.56	1	6
Partial mimic	1.24	1.04	1	4

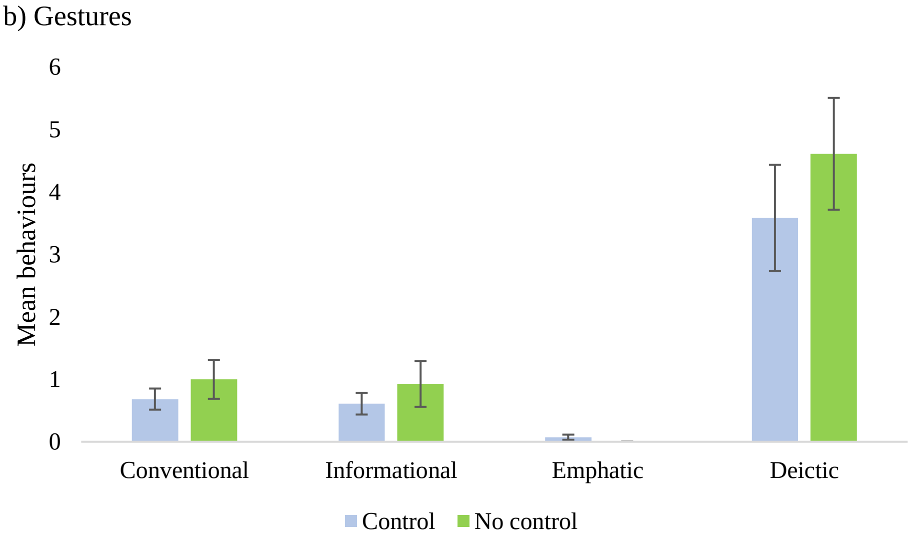
Table A4. Paired samples t-tests comparing control and no control on social, gesture and mimicry variables (df=40)

	t	*p*	*d*
Social			
Showing	-0.40	.69	.02
Requesting	-0.67	.50	.13
Offering information	-0.79	.44	.06
Asks for information	0.33	.74	.08
Shared enjoyment	0.75	.46	.13

Gesture			
Conventional	-0.93	.36	.20
Informational	-0.93	.36	.17
Emphatic	1.78	.08	-
Deictic	-1.26	.21	.18
Mimicry			
Full	-1.70	.10	.30
Partial	-0.63	.54	.11

- Effect size could not be calculated for emphatic gestures as M=0 in no control.





c) Mimicry

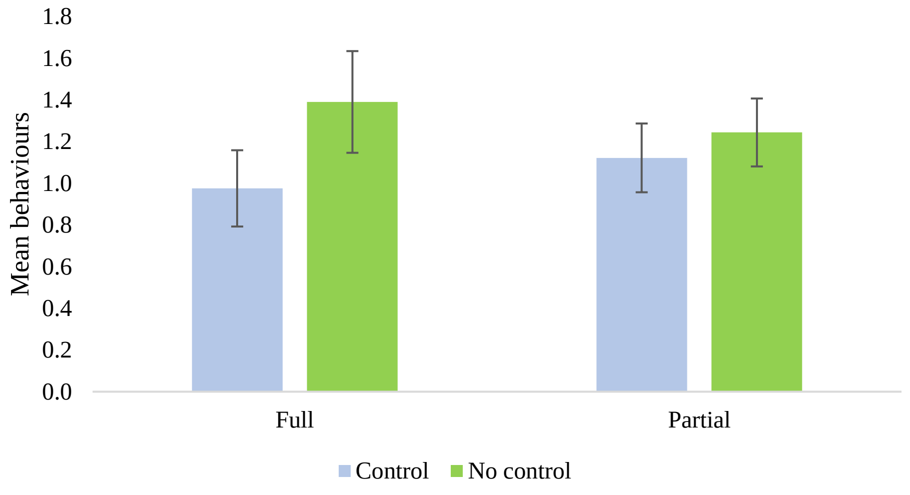
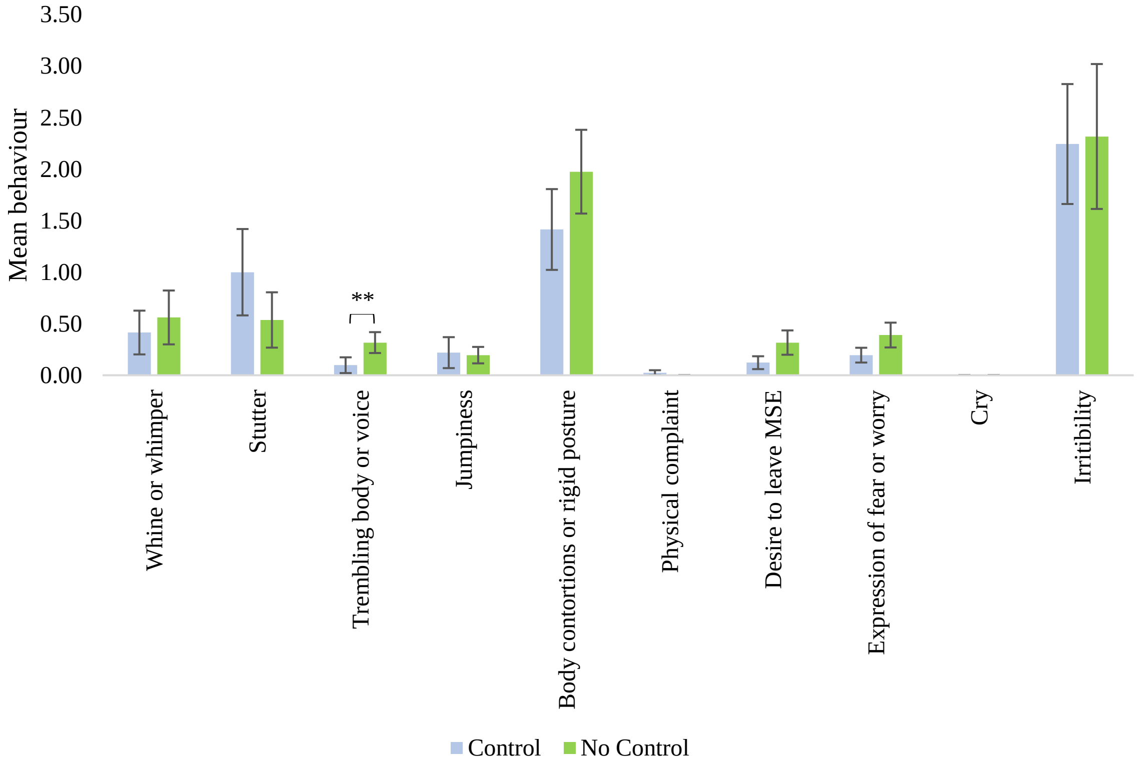


Figure A1. Individual a) social behaviours, b) gestures, and c) mimicry between the control and no control condition. +/- standard error bars.

Appendix H: Means of individual anxiety and enjoyment codes (Chapter 4)

Descriptives

a) Anxiety



b) Enjoyment

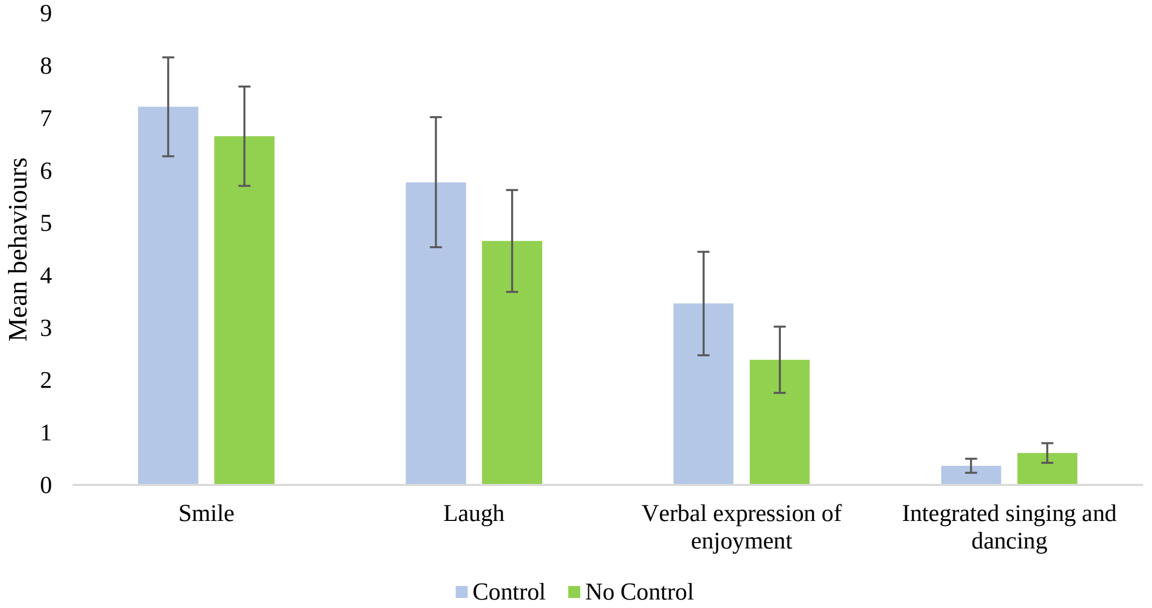


Figure A2. Mean a) anxiety, and b) enjoyment behaviours between conditions. +/- standard error bars.

Inferentials

Table A5. Paired samples t-test of individual anxiety and enjoyment behaviours between conditions (df=40)

	t	*p*	*d*
Anxiety			
Whine/whimper	-0.77	.45	.10
Stutter	1.68	.10	.20
Trembling	-2.96**	.01	.38
Jumpiness	0.14	.89	.03
Body contortions	-1.57	.13	.22
Physical complaint	1.00	.32	-
Desire to leave	-1.43	.16	.33
Expression of fear or worry	-1.60	.12	.30
Irritability	-0.15	.88	.02
Enjoyment			
Smiling	0.64	.53	.09
Laughing	2.01	.05	.16
Verbal expression of enjoyment	1.58	.12	.20
Integrated singing and dancing	-1.33	.19	.23

N.B. The code "Crying" is not included here as there was no crying coded in either condition
- Effect size could not be calculated for "Physical complaint" as M=0 in no control.