THE USE OF A KINECT-BASED TECHNOLOGY WITHIN THE SCHOOL ENVIRONMENT TO ENHANCE SENSORY-MOTOR SKILLS OF CHILDREN WITH AUTISM

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A Thesis Submitted to

The University of Birmingham

for the Degree of

DOCTOR OF PHILOSOPHY

School of Education

The University of Birmingham

March 2016

ABSTRACT

This research explored the effect of Pictogram Room, a Kinect-based technology, on the sensory-motor skills of children with autism in a school setting. It focused on the overall development of sensory-motor skills, how these skills developed in different environments, and which of the sensory-motor subdomains improved the most. Theoretically, the study drew upon gaming theory and embodied cognition. It was a mixed methods study, with the quantitative data being the dominant method of data collection and the qualitative data having a more supportive role. During the first year, the intervention was implemented with the intervention group (n=5), twice a week for 15 minutes, over the course of nine weeks. The following year, a wait-list control group was recruited (n=5). The findings from the researcher's checklist, as well as those from the standardised assessments, showed that sensory-motor skills in the intervention group were significantly improved, and there was also generalisation of these skills to other environments. Finally, as a result of the teachers' interviews, social play and adaptive behaviours were also evaluated, with positive results for the intervention group.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my supervisors, Dr Karen Guldberg and Dr Kerstin Wittemeyer. Their guidance and support inspired me and kept me and it is still keeping me strong.

A big loving thank you to all the members of my family, who have always been there for me. A warm thank you to my dear friends Lila and Patricia who have been like a second family to me these years.

I would also like to thank all the children and the staff who participated in the study. Without their help and commitment, this research would not have been possible.

Finally, I would like to thank Claire Robson for her invaluable help with checking the spelling and punctuation of my writing.

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LIST OF ABBREVIATIONS

ABA	Applied Behavior Analysis
ADI	Autism Diagnostic Interview
APA	American Psychiatric Association
AS	Asperger Syndrome
ASD	Autism Spectrum Disorder
BBAP	Balance, Body Awareness and Planning
BEERY^{TM}VMI	Beery-Buktenica Developmental test of Visual-Motor Integration
BERA	British Educational Research Association
BPVS	British Picture Vocabulary Scale
CPM	Colored Progressive Matrices
DSM	Diagnostic and Statistical Manual of mental disorders
GBL	Game-Based Learning
KLA	Kinesthetic Learning Activity
MABC	Movement Assessment Battery for Children
MRC	Medical Research Council
NICE	National Institute for Health and Clinical Excellence
PE	Physical Education
RCT	Randomised Control Trial
SCERTS	Social Communication Emotional Regulation Transactional Support
SCQ	Social Communication Questionnaire
SD	Standard Deviation
SPA	Social Play Assessment

SPM	Sensory Processing Measure
SSP	Short Sensory Profile
TD	Typically Developing
TEACCH	Treatment and Education of Autistic and related Communication handicapped Children
ToM	Theory of Mind
UDL	Universal Design for Learning
VABS	Vineland Adaptive Behavior Scale
WHO	World Health Organisation

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CHAPTER 1

INTRODUCTION

1.1 Origins of the study

More research is needed on how teachers can accommodate the needs of children with autism in specialist, special or mainstream settings given that estimates of prevalence range from 60/10,000 (Medical Research Council: MRC, 2001) to 116/10,000 (Baird et al., 2006), leading to the likelihood that every teacher will at some point teach a child with autism. Furthermore, current estimates indicate that more than 80% of children with autism exhibit co-occurring sensory processing problems (Ben-Sasson et al., 2009), and hyper- or hypo-reactivity to sensory input is now a diagnostic criterion for autism in the Diagnostic and Statistical Manual of Mental Disorders—Fifth Edition (DSM-5; American Psychiatric Association: APA, 2013). Individuals with these sensitivities, and their families, report that they significantly restrict full participation in daily activities and create social isolation (Dickie et al., 2009; Schaaf et al., 2011).

In fact, since Kanner's investigation of autism in 1943 (Kanner, 1943), it has been recognised that individuals with autism might often present sensory processing difficulties. Sensory processing difficulties include limited body awareness (proprioception), balance problems (vestibular processing), tactile challenges, fine motor and/or perceptual problems, auditory sensitivity, self-regulation difficulties, and oral sensory sensitivity (Ayres and Tickle, 1980; Ermer and Dunn, 1998; Baranek, 2002). The sensory processing difficulties of vestibular and proprioceptive processing have received less scientific attention than the others. This is surprising given the multitude of studies that have documented difficulties in motion and balance in individuals with autism (e.g. Minshew et al., 2004; Ming, Brimacombe and Wagner, 2007; Fournier, Hass, Naik, Lodha, and Cauraugh, 2010; Fournier, Kimberg, et al., 2010; Bhat et al., 2011) and proprioceptive processing (Weimer et al., 2001; Molloy et al., 2003; Minshew et al., 2004). The researcher therefore decided to focus her study on these two systems.

These systems along with input from the visual system comprise the sensory-motor or sensorimotor skills (Siaperas, 2012). Sensory-motor processing refers to the integration of information received from the senses, enabling efficient motor performance (Blakemore et al., 1998; Bonifacci, 2004). According to Dr J. Ayres, the definition of sensory-motor skills also extends to cognitive tasks that are related to the understanding of the motor activity or task (Ayres, 1972; Siaperas, 2012). This process is called motor planning (Hill, 2004; Parham et al., 2007). The researcher followed Dr J. Ayres' definition and, therefore, this study will include planning skills (Parham et al., 2007) too. The output of the processing through the vestibular and proprioceptive systems, besides motor planning, extends to gross and fine motor skills (Siaperas, 2012). However, the researcher did not assess those in the participants, as direct measurement of these skills (e.g. Sensory Integration and Praxis tests; Ayres, 1989) required qualifications that the researcher did not have and no occupational therapist was available to administer them.

As there are incomplete and contradictory findings from research, the field lacks consensus as to what sensory-motor interventions families should seek and what practitioners can recommend (Case-Smith et al., 2014). Furthermore, a number of studies describe the differences individuals with autism have in sensory processing, but very few of them measure the effects of various interventions on these differences (Baranek, 2002; Baranek et al., 2005; Germani et al., 2014). Although preliminary data on interventions addressing sensory-motor difficulties in autism is promising (May-Benson and Koomar, 2010), there is a need for more systematic and methodologically rigorous investigations of existing widely used approaches, such as traditional occupational therapy, sensory integration and physical exercise, in order to evaluate their safety, acceptability, efficacy, and effectiveness. One possible reason to why these interventions have not been widely researched may be because of the different approaches and elements various people incorporate, thus making it harder to draw conclusions. For example, physical exercise can vary from simple jogging to horseback riding (e.g. Bass et al., 2009) or swimming (e.g. Yilmaz et al., 2004) and each of these require different skills and training.

In the last few years, a number of Technology Enhanced Learning (TEL) interventions have increasingly been used to support individuals with autism. Although research evidence is still mixed, there are clear indications that technology holds great benefits for children with autism (Battocchi et al., 2008). Technology can offer these children an assistive learning environment and help them develop different skills and knowledge. This is because it can offer a predictive and safe environment in which they can practice new skills without the fear of failure or the social anxiety that may accompany real-life situations (Battocchi et al., 2008; Putnam and Chong, 2008). Technology has been used to help individuals with autism in order to increase their social skills (e.g. Hetzroni and Tannous, 2004), help with recognition of emotions (e.g. Baron-Cohen, Golan, Wheelwright and Hill, 2004), develop academic skills (e.g.

Bosseler and Massaro, 2003), and encourage imitation (e.g. Dautenhahn and Werry, 2004).

Recently, with the development of two unique technology devices that allow free body movement, sensory-motor skills development in individuals with autism are now being explored (e.g. Zalapa and Tentori, 2013) through the use of technology. These devices are the Nintendo Wii and Xbox/Microsoft Kinect, both offering a motion based interaction environment. The potential of motion-based interaction for learning is grounded on theoretical approaches, which recognise the relationship between physical activity and cognitive processes (Tomporowski et al., 2008; Gligoroska et al., 2012). This is also referred to as embodiment, the way in which an individual's sensory-motor capacities enable him or her to successfully interact with the physical environment (Broadhurst and Machon, 2006). One such technology that builds upon embodiment and allows free body movement is Pictogram Room. Pictogram Room is a set of Xbox/Microsoft Kinect-based educational video games designed for working on key areas of development in children, adolescents and adults with autism. Individuals can progress through basic aspects of communication, joint attention, body shape and imitation, in a playful and entertaining way. Using visual and musical aids, the student initially has access to several different video games in order to encourage him or her to learn, while also drawing on their strengths. The games are visual, incorporating music and the use of one's own body. The Pictogram Room project was funded by the Orange Foundation in Spain who were also the main developers along with the University of Valencia. Partners in this project were the University of Birmingham, the University Pompeu Fabra, the Adapta Foundation, the Autism Burgos, the Autism Avila, the Fundació Mira'm and the Mobimea.

The researcher was first attracted to Pictogram Room due to her professional passion in creating an environment for children with autism, enabling them to work in a fun and engaging way, while also increasing their skill set. When she started working as a teacher of children with autism in Greece, she found that many of these children had problems with their sensory-motor development. They often found it hard to have a sense of, and control, their body in their environment and also had difficulty completing tasks that required multiple steps. The professionals who usually dealt with these issues were the occupational therapists, whose work was invaluable. However, schools did not have the funding to have an occupational therapist full-time and they were not available for every child. They were usually available in the school to work with the children for about 15 minutes, once or twice a week. This experience led the researcher to want to explore potential alternative ways in which teachers could support their students in the development of these skills. As a consequence, she came to the UK to do a Masters in Autism and then continued to undertake a PhD study. She wanted to have the experience of working in another country and, through her studies, to see the potential ways that she could contribute to the development of her students' skills and then share these with other professionals. When she started working in schools in the UK she realised that there were similar issues, in terms of access to occupational therapy, as in Greece, so this work could contribute to schools in both countries.

Although approaches to addressing sensory-motor development in autism, such as traditional occupational therapy, physical education and the sensory-motor integration approach do have positive results and are of great importance for children's development, there are practical constraints. They usually require trained personnel, organised places for specific purposes and equipment that is usually very expensive (Ganz, 2007). Having interventions that only trained personnel can deliver is costly and not all schools have the same resources. Thus, the researcher started to explore potential ways to overcome these limitations and give teachers and parents another tool to help children with autism. Just before the researcher started her PhD studies, there was growing evidence about the use of Serious Games (i.e. games that besides being fun are also used for educational purposes) in the education of children with autism, and their effectiveness in various areas of skill development (Noor, Shahbodin and Pee, 2012). The researcher met with one of the teams, who undertake game development for autism, in Spain. They were working on Pictogram Room and she had the chance to see their software. She decided as part of her PhD studies to explore the potential of this Kinect-based technology to test whether it could help students with autism increase their sensory-motor skills. She saw the potential of Pictogram Room as an intervention tool that was going to be used, not only by researchers, but also by parents and teachers, whilst being available for free. Consequently, as a teacher she wanted to research how this environment could be used in order to help pupils to improve their sensory-motor skills.

This thesis reports a study on the sensory-motor development skills of children with autism, by using Pictogram Room to help students with autism enhance their sensory-motor skills, through adaptation of the activities and the environment to meet their needs. By allowing full body input to manipulate the environment, the activities are directly targeting these skills, and the children work in collaboration with the researcher to complete the various steps of the intervention. So, rather than giving the children something set and pre-determined, it is adapted to meet their individual differences (e.g. preference for colours, sound, etc.). The overall aim is to see whether the interaction with a software can help children develop their sensory-motor skills, enhance their social play and adaptive behaviours and, consequently, provide the teachers with a tool they can use to help their students, in addition to or in the absence of occupational therapy.

1.2 Theoretical frameworks

This study draws upon the gaming theory in education and the embodied cognition framework. These two theories helped the researcher decide on the intervention she would carry out as well as the tool she would use for its implementation. According to the gaming theory, educators and other learning scientists can leverage the motivation that children have for technology and video games, for educational and pedagogical purposes. Research in the game design field has indicated that platforms using the qualities of video games in a non-game context (e.g. classroom) can maximise learning (McGonigal, 2011; Kim, 2014); this is what designers call 'smart gamification' (Kim, 2014). Pictogram Room offers a set of activities in a video game-like environment, which can be used in a classroom, or home context, for educational purposes. It can offer a) the challenge of completing a game; b) imagination to control the virtual objects; c) curiosity to explore the environment and d) control for the game. These four heuristics are recommended for developing user computer interfaces (Malone and Lepper, 1987). Video games build on the strength of the learner and provide opportunities for repetition, control and adaptation to the user's needs (González, Cabrera, and Gutiérrez, 2007). Thus, the children participating in the study would have the chance to work on skills needed for everyday life through a fun and engaging way.

The theoretical framework of embodied cognition builds upon the notion that bodily experiences play a crucial role in human cognition. Furthermore, an individual's experiences are stored in a manner that maps onto the original neural systems (motor, visual, olfactory, and auditory) that encoded them in the first place (Eigsti, 2013). In this formulation, the ability to represent objects and events is facilitated by sensor-motor systems that govern interactions with objects and events (Barsalou, 1999). When objects and events are recalled from memory to serve action goals, the sensory-motor systems involved in their initial representation are reactivated. So far, embodiment in autism has been mostly studies in social contexts, but Eigsti (2013) suggested that embodiment in autism might go beyond these and embody all their experiences differently, including sensory-motor ones. The Kinect sensor, that Pictogram Room also uses, can allow the user to actively participate in activities and get real time visual feedback of his or her actions (Kim, 2014). Therefore, the user can practice sensory-motor skills in Pictogram Room and, by actively participating in the activities, he or she can recall those actions and improve his or her skills.

1.3 Research questions

The researcher used Pictogram Room, which includes a set of Kinect-based games that can be personalised to meet children's needs, to test its impact on children's sensory-motor skills.

<u>The main research questions of the study were:</u>

1. Can Pictogram Room enhance the sensory-motor skills of children with autism?

2. In which environment/s do the sensory-motor skills of the children with autism

develop to a greater extent (i.e. Software, Classroom, Home, Physical Education, Playground)? Were they generalised outside the Software environment?

3. Which sensory-motor sub-domain improved more (i.e. Balance and Motion, Body Awareness and Planning and Ideas)?

4. Are the findings of the first three research questions different when just analysing the data from an intervention group compared to when comparing the intervention to a control group?

5. What are the ways that Pictogram Room can be used in a school setting?

<u>Post hoc research question from the teachers' interviews:</u>

6. Were there any differences in social play and adaptive skills between the intervention and the control group?

1.4 Research design and methodology of the study

In order to answer the above research questions, the researcher chose a mixed-methods design, gathering both quantitative and qualitative data for her study. She chose this method for triangulation purposes, so as to provide better validity of the results and to also answer different research questions. The mixed-methods design type she followed for the study was a partially mixed sequential dominant status (Leech and Onwuegbuzie, 2007). The dominant part was the quantitative data, and the qualitative data, although important, had a more supportive and secondary role.

The study utilised a single-subject approach to see the effectiveness of the intervention in the intervention group, and a group-design approach to see potential differences between the intervention and the control group. These two approaches were used to gather the quantitative data through a checklist developed by the researcher and standardized assessments. In addition to that, interviews with teachers were conducted to gather the qualitative data. These two designs are very different, and although experimental designs might be more rigorous (Horner, Carr and Halle et al., 2005), the researcher felt that their use alone might not have been enough to capture the ecological realities of the classroom.

The researcher video recorded the children in both groups, in different school environments, and used a checklist she developed, the Balance, Body Awareness and Planning (BBAP), to code children's sensory-motor skills. Also, for the same purpose, she asked parents and teachers to complete a standardised assessment, called Sensory Processing Measure (SPM; Parham et al., 2007), that has specific measures of Body Awareness, Balance and Planning and ideas. These methods were used to answer the first four research questions and the researcher analysed these for the intervention group alone, and for the comparing the intervention group to the control group. The teachers' interviews had multiple purposes. Firstly, they were used to see whether their observations regarding the intervention group's sensory-motor skills matched the quantitative data. In addition, they were used to answer the fourth research question, regarding the way in which Pictogram Room can be used in schools. Part of what they reported was about the development of social play and adaptive behaviour in the intervention group. Hence, the sixth research question emerged. To test social play skills, the researcher used a checklist she developed, called the Social Play Assessment (SPA) and coded the children's videos in different environments. To test adaptive behaviour she used a standardised assessment, the Vineland Adaptive behaviour Scales–II (VABS-II; Sparrow, Cicchetti and Balla, 2005) the Teacher's Edition.

The researcher worked in close collaboration with the staff to decide which activities would be used for the targeted skills. The contribution of the staff was very important in the study. There was a democratic partnership between the researcher and the staff, which empowered and developed both (McNiff and Whitehead, 2006; Denscombe, 2010). This was because the researcher was not aware of children's needs and how the school schedule worked. Teachers spent time with her, choosing the right activities and also figuring out the best way to work with Pictogram Room, in terms of setting and amount of time. On the other hand, teachers needed more input on how to support their students' sensory-motor skills and the researcher tried to use a fun and engaging method of targeting those skills, providing more opportunities for intervention in this area.

As pointed out by Parsons and Kasari (2013, p. 251), school is the natural environment where children spend most of their time and conducting research in schools can 'increase research samples of children to include those who are traditionally underserved, underrepresented and under-resourced'. Compared to interventions that take place in labs or clinics, the main advantage of school-based studies is that they have high ecological validity and provide findings which can be directly transferred into similar settings, (Kasari and Smith, 2013). Additionally, conducting real world research is recommended to investigate the impact of different interventions in autism (Reichow et al., 2008). Therefore, a mainstream school which has three autism resource base units was chosen as the setting for this study. The sample consisted of five children in the intervention group and five children in the wait–list control group, aged between four and six years old, all attending the reception class. The age range of the children chosen was based on the rationale of understanding the importance of early intervention for children with autism (Powell and Jordan, 1997; Rogers and Dawson, 2010). All children followed an extended curriculum and all had learning difficulties, as there was a gap in studies using pupils with learning difficulties in intervention studies (Baranek, 2002). Finally, three members of staff (three teachers) participated in the study. All three completed the relevant assessments about the children but only two of them participated in the interviews.

1.5 Significance, aims and purposes of the study

There are multiple reasons why this study is relevant and contemporary. As mentioned previously, prevalence of difficulties in sensory-motor skills is very high and there is a gap in the literature regarding interventions to facilitate improvements in this area. Although there are approaches that have been widely used for the development of these skills, (e.g. sensory integration therapy), most of them require specialised equipment and trained personnel, which makes them hard and expensive to be delivered. This study tests the impact of a new technology environment for sensory-motor skills intervention in individuals with autism in a school setting. Pictogram Room is a fun play-based way to enhance the skills of children with the Kinect allowing whole-body input, thus making it a good fit for working on sensory-motor skills. Additionally, it does not require specially trained personnel and is cost-effective.

1.6 Organisation of the thesis

This thesis is divided into eight chapters including this introduction (i.e. Chapter One). Chapters Two and Three review the literature. Chapter Two starts by the exploration of sensory-motor development in both typically developing children and children with autism and highlights the difficulties that the latter might face in these areas. Additionally, theories behind sensory-motor development are explored. Chapter Three focuses on current interventions used to address these issues and explores the potential of new technologies as a new approach for intervention. Chapters Four and Five focus on the design and methodology used to carry out the study. Chapter Four gives an overview of the study design, the philosophical underpinnings, the aims, the research questions, the research methodology and concludes with the sample and setting characteristics. Chapter Five outlines the phases of the study, explains how Pictogram Room was delivered, how the research methods were developed and used, reports notes on the analysis, and reports on the study's validity, reliability and the main ethical issues arising. Chapter Six presents the findings of the study. The first section includes the findings in the development of sensory-motor skills overall. The second section presents the findings on five different environments including the Software environment, Home, Classroom, Physical Education (PE) and Playground. The next section explores the results on the three sub-domains of sensory-motor skills, as defined by the researcher, including Balance and Motion, Body Awareness and Planning and Ideas. The aforementioned findings are reported for the intervention group alone and between the intervention and control group. The Chapter also reports the results of teachers' interviews regarding the intervention's group sensory-motor skills and on how Pictogram Room can be used in the school setting. Chapter Seven discusses the findings of the study. Finally, Chapter Eight summarises the most significant findings, discusses the limitations of the study and proposes ideas and implications for practice and future research.

1.7 A note on terminology used in the study

There is no universal agreement on how individuals with autism feel about being autistic nor a specific term used to describe how they would like to be 'referred to'. Some people say they would like to get rid of their autism as it makes life hard for them. Blackburn (2007) states that she considers herself *socially disabled.* However, others see their autism as part of themselves and they do not consider it a disorder. For example, Jackson (2002), a young man with AS, views autism as '*a name for a lifelong set of behaviours'* (p. 29). Furthermore, a revision to Autism Spectrum Disorder (ASD) was proposed in the fifth edition of the DSM (APA, 2013). The new diagnostic category encompasses previous diagnoses of autistic disorder, Asperger's disorder, childhood disintegrative disorder, and Pervasive Developmental Disorders-Not Otherwise Specified (PDD-NOS). However, the researcher has decided to use the term autism instead of ASD in this thesis. This was decided after taking into account people with autism's feelings and acknowledging the power of language when referring to people with special needs (Runswick-Cole and Hodge, 2009). Also, terms such as disorder or disability were rejected as promoting the medical model of disability. Additionally, Autism Spectrum Condition can be used to refer to individuals with an autism diagnosis but this was rejected by the researcher as the term condition did not seem adequate to describe the extent to which some people's lives are affected by autism. The term autism, in this thesis, refers to the whole autism spectrum such as AS, Kanner's autism, atypical autism, PDD-NOS, which is in line with how the term is used by Jordan (1999) and the National Institute for Health and Clinical Excellence (NICE) guidelines (clinical guideline 128, 2012).

Furthermore, the researcher wants to make a distinction between the terms 'efficacy' and 'effectiveness' when referring to interventions. Although she uses both terms, it is important to note that there is a difference between them. Efficacy mostly refers to experimental studies investigating intervention outcomes. This is because they tend to report the success or failure of an intervention, when implemented in a rigorous way, in controlled environments (de Bruin, 2015). On the other hand, she uses effectiveness to refer to the success or failure of an intervention, in terms of its perceived importance and sustainability, by or for those individuals who are involved in it in everyday conditions (Weisz and Jensen, 1999; de Bruin, 2015).

1.8 Funding body

Before moving on to the main body of this thesis, it is important to acknowledge that the research has been funded by the Greek Public Benefit Foundation, namely the Onassis Foundation. The Foundation had no role in the study design, the data collection, analysis, interpretation or writing of the thesis. The only obligation the researcher had towards the Foundation was to acknowledge it when publishing or presenting at conferences.

CHAPTER 2

LITERATURE REVIEW: SENSORY-MOTOR SKILLS IN AUTISM

2.1 Introduction

As mentioned in Chapter 1, current estimates indicate that 80% of children diagnosed with autism present sensory processing problems (Ben-Sasson et al., 2009). This thesis explores the effect that a Kinect-based video game, called Pictogram Room, has on children with autism's sensory-motor skills (a subset of sensory processing skills that are related to movement). More specifically, the researcher focuses on balance (vestibular), body awareness (proprioception) and planning skills. This chapter is the first of two chapters that reviews the relevant literature and is written in ten sections.

The Chapter starts by examining typical sensory-motor development and indicates the problems that may be present, in relation to these skills, in children with autism. It continues with specific references to vestibular and proprioceptive processing in autism, as well as planning behaviour, as the researcher focuses on these skills for the purposes of the study. Also, the relationship of sensory-motor skills with other behaviours is presented. Furthermore, there is a discussion on the traditional cognitive theories of autism and the need for a new theory to explain the diverse range of autism characteristics. It then makes reference to Sensory Integration theory and how different researchers have interpreted it and linked it to the theory of optimal arousal. The chapter concludes with discussing a theory of learning dependent on motion-based gaming and provides a summary.

2.2 Typical sensory-motor development

This section examines the sensory-motor development in typically developing children, in order to provide a context within which to analyse the sensory-motor skills of children with autism. This is limited to a discussion of development from birth to seven years old, as it is close to the chronological age of the participants.

Infancy and childhood are periods of significant neurological development and change. A child's nervous system is immature at the time of birth and, therefore, is growing and developing throughout childhood (Gerber, Wilks and Erdie-Lalena, 2010). However, during this process a number of factors can influence the rate and quality of this growth and also, therefore, the development of sensory-motor skills. These influencing factors include genetically determined attributes and lifestyle habits, both inherited and cultural (Gerber, Wilks and Erdie-Lalena, 2010). Jean Piaget described the association between senses and physical learning (Piaget and Inheler, 1969). Early movements made by infants are predominantly involuntary or reflexive. To explore the environment, infants use the senses of vision, touch, smell, hearing and movement, as well as vestibular awareness (sense of balance) and proprioception (sense of body position). Through this process, children's thoughts and logic move from abstract to concrete (Piaget and Inheler, 1969). Bearing this in mind, it is apparent that sensory-motor skills develop gradually, with input from the sensory system. Different stages can be identified in this process, known as developmental milestones and are described below.

2.2.1 Sensory-motor developmental milestones

At one month of age, babies' neck muscles are not developed enough to support their heads for prolonged periods of time. Babies can lift their heads only briefly when lying on their stomachs. Limb movements are influenced by newborn reflexes. These include the startle reflex, which causes a baby to throw out his or her arms and spread the fingers in response to a loud noise or other sudden, unexpected stimulus (Gerber et al., 2010). By six weeks of age, newborn reflexes begin to fade and the baby's strength and coordination improve. From that point, until about the fourth month, infants' behaviour is mostly focused on their own bodies, what Piaget calls primary behaviours (Piaget and Inheler, 1969). Slowly babies' reflexes develop a meaning or they perform an action deliberately and usually in a repetitive way. For example, an infant might grab his or her mother's finger and put it in the mouth. After the fourth month until about the eighth, infants' behaviours become secondary, meaning that they become more aware and more responsive to the outside world and realise that that their behaviour can have an effect. They also have improved balance, they gain coordination of large muscles and they can sit independently most of the time. By twelve months, infants explore the world with all their senses and engage in more goal-directed actions. At the same time, they have better control of their hands and fingers and are able to manipulate smaller objects. Additionally, they progress to crawling, standing position and/or walking. It is worthwhile to note that many toddlers start to walk around nine to fifteen months of age (Gerber et al., 2010). By eighteen months, the child climbs on furniture, climbs up and down stairs with some support and begins to run usually in an uncoordinated way. At the age of twenty-four months, the child jumps off a step, throws a ball and goes down a slide. Between two and three years, the child can climb well, kick a ball without losing balance, balance on one foot, run with good coordination and begins to hop on one foot. By the age of five years, the child jumps, hops, climbs, skips, swings, rides a tricycle, balances on one foot without support for many seconds and catches a ball consistently. However, not all children follow these developmental sensory-motor milestones and might present difficulties in various areas. These difficulties are often referred to as sensory integration dysfunction, which is discussed below.

2.3 Sensory integration dysfunction

Sensory integration dysfunction or sensory processing dysfunction, is commonly defined as the difficulty to modulate, discriminate, coordinate or organise sensation adaptively in the environment (DiMatties and Sammons, 2003). Signs of a sensory integration dysfunction include, but are not limited to, hyper- or hypo-sensitivity to touch, poor coordination, and poor behavioural control (Ramirez, 1998). For example, a child with autism, who might have sensory dysfunction, may not have the same response to touch, taste, and sounds as a typically developing child. Sensory problems are widely believed to affect individual's performance in daily life activities and tasks (Bundy, et al. 2002). Even though sensory dysfunction affects the child on a regular basis, the type of sensory issues he or she experiences may vary from day to day. Individuals who struggle with sensory dysfunction often receive different interventions to overcome their difficulties. Professionals who provide these interventions (usually occupational therapists) engage individuals in sensory activities that elicit positive responses (Bundy, et al. 2002). The response can be any type of reaction from the individual, such as ability to concentrate on a given task, an unexpected interaction, a change in temperament, initiation of an activity, or a communication attempt. The sensory activities can vary from a bear hug, trying foods, listening to music, or smelling something new. If this process is envisioned in a schematic representation, there is a continuous circle of intervention taking place. It starts with the sensory intake, as mentioned in examples above, which leads to the central nervous system for processing. The child's brain then plans and organises the behaviour, leading to the output, which can be a behaviour or learning. The output then yields a response or feedback (Bundy, et al. 2002).

2.4 Sensory integration difficulties in autism

Since Kanner's investigation of individuals with autism in 1943 (Kanner, 1943), it has been recognised that these individuals may often manifest sensory integration or sensory processing problems that may include, among others, (a) low endurance and tone, (b) clumsiness, (c) tactile challenges, (d) fine motor and/or perceptual problems, (e) self-regulation difficulties, and (f) oral sensory sensitivity (Ayres and Tickle, 1980; Kientz and Dunn, 1997; Ermer and Dunn, 1998; Bagnato and Neisworth, 1999). Although sensory processing difficulties in autism were demonstrated for many years, and in various studies (Baranek, 2002; Rogers and Ozonoff, 2005; Ben-Sasson et al., 2007; Tomchek and Dunn, 2007; Hilton et al., 2010), hyper- and hypo-reactivity to sensory input did not become part of the diagnostic manual until the release of the DSM-5 (APA, 2013).

Researchers are beginning to consider these sensory processing difficulties as a core feature of autism that may lead to the later difficulties in language and other everyday problems (Marco et al., 2011). The body of research reviewed is somewhat difficult to interpret, due to the variety of different measures used (i.e., report measures vs. observational measures), the different individuals reporting (i.e., parents or caregivers vs. self vs. teachers or other staff), the inclusion of different sensory modalities within one study, the different samples of individuals with varied levels of autism severity and the different ages of the subjects included. There is also a question of whether children with autism are hypo-responsive or hyper-responsive to sensory input. A number of studies have reported both of these sensory responses in individuals with autism (Baranek, Boyd, Poe, David and Watson, 2007; Foss-Feig et al., 2012). Other studies have found both patterns within the same sample of individuals (Kientz and Dunn, 1997; Ben-Sasson et al., 2009; Lane, Young, Baker, and Angley, 2010). Although some of these studies have suggested that hypo-responsiveness is most common in individuals with autism, compared to typically developing individuals (Rogers and Ozonoff, 2005; Baranek et al, 2006; Ben Sasson et al., 2007; Foss-Feig et al., 2012), others are beginning to disregard the importance of the construct of responsiveness. This is because an individual may be over-responsive to some sensations and under-responsive to others (Schoen et al., 2009; Lane et al., 2010). Another debatable question is which forms of sensation are most difficult for individuals with autism. Studies have found that individuals with autism may have difficulty with all sensory systems to varying degrees. Whereas visual processing often appears to be a strength, auditory processing, taste, smell processing, and tactile processing including oral tactile most frequently appear to cause difficulty in this population (Rogers et al., 2003; Leekam et al., 2007; Tomchek and Dunn, 2007; Ben-Sasson, et al. 2009; Chen et al., 2009; Hilton et al., 2010).

The majority of existing research on sensory processing within the individual modalities in autism has focused on the auditory and visual systems; however, a recent study specifically examined tactile processing in individuals with autism (Foss-

Feig et al., 2012). Parent questionnaires and direct observation were both used to collect data from a sample of 34 children with autism. Tactile seeking and hypo-responsive behaviour were associated with social difficulties and repetitive behaviour, whereas hyper-responsiveness was not associated with characteristics of autism. Another study similarly found tactile sensory seeking and the enjoyment of tactile experiences, such as air blown by a fan, in participants with autism (Pernon, Pry and Baghdadli, 2007). Other studies have suggested atypical tactile processing in those with autism (Baranek, and Whitesel, 2008; Tannan, Holden, Zhang, Baranek, and Tommerdahl, 2008), and others have further suggested intact tactile functions (O'Riorden and Passetti, 2006; Guclu et al., 2007; Cascio et al., 2008).

Less scientific attention has been paid to problems with vestibular and proprioceptive processing in individuals with autism. This is surprising given the multitude of studies that have documented difficulties in motion and balance in these individuals (Minshew et al., 2004; Ming, Brimacombe and Wagner, 2007; Fournier, Hass, Naik, Lodha, and Cauraugh, 2010; Fournier, Kimberg, et al., 2010; Bhat et al., 2011). However, there are also several studies that have documented difficulties with proprioceptive processing. Individuals with autism have been found to have typical somatosensory processing in relation to postural control (Weimer et al., 2001; Molloy et al., 2003; Minshew et al., 2004) and problems in the coordination of grip force (David et al., 2009), suggesting difficulties with motor planning and somatosensory function. However, individuals with autism, who present hyper-sensitivity to movement and proprioception, performed as well as those without autism on tasks requiring proprioception (Fuentes, et al., 2010). Participants with autism in the Fuentes et al. (2010) study were able to move a robotic arm to an appropriate location accurately with their eyes closed, suggesting typical proprioceptive functioning. As mentioned previously, for the purposes of the study the researcher focuses on vestibular awareness, proprioceptive processing and planning difficulties. These are amongst the most under-researched sensory processing skills and there is a need for increased information. These are described in the next sections.

2.4.1 Vestibular processing and autism

The vestibular system refers to the structures within the inner ear (the semi-circular canals) that detect movement and changes of head position. It also provides information about whether the child is moving or being stable, movements of the objects and their relation to the body, as well as the direction and speed of the child's movement. This information is received through the eyes, muscles, joints, skin, and the cerebellum (Kandel, Schwartz and Jessell, 1991). Dysfunction within the system is presented in two different ways. Firstly, children may be hyper-sensitive to vestibular stimulation and this leads to fearful reactions to common movement activities (e.g., swings, slides). They may also have trouble in climbing stairs and when walking or crawling on uneven or unstable surfaces. As a result, these children appear clumsy. On the other hand, there are children that actively seek intense sensory input, such as jumping and spinning. This is referred to as sensory seeking, which describes behaviours that reflect a desire for certain types of sensory stimulation (Foss-Feig et al., 2012). In this case, children demonstrate a hypo-sensitive vestibular system. However, there are children that can present both types (Hochhauser and Engel-Yeger, 2010).

Since 1979, there have been published reports of vestibular problems in autism (Maurer and Damasio, 1979). They may demonstrate slow and/or unusual walking, shorter strides, increasing knee flexion, as well as unusual upper extremity positions (Vilensky et al., 1981). These difficulties may make the children feel vulnerable when their feet leave the ground and they continuously worry about falling down (Kranowitz, 1998; O'Roidon, 2000; Bahr, 2001). Moreover, problems with posturing, balance and eye movements have also been reported. Molloy, Dietrich, and Bhattacharya (2003), for example, found that eight children with autism had significantly larger sway areas than eight matched controls. Additionally, motor control problems are also reported (Vernazza-Martin et al., 2005). Although individuals with autism are capable of developing numerous motor skills in time, some of these skills may develop later than chronologically aged-matched peers. These motor problems observed in children with autism are usually related to motor coordination problems. Finally, it is suggested that their motor readiness levels for executing an action are low in comparison to the typically developing children (Attwood, 1998; Ryoichiro et al., 2000; Beversdorf et al., 2001).

2.4.2 Proprioceptive processing and autism

The proprioceptive system refers to components of muscles, joints, and tendons that provide a person with a subconscious awareness of movement and body position. It plays a crucial role in daily life, since it contributes to the development of motor skills and the general ability to successfully interact with the environment (Bogdashina, 2003). When proprioception is functioning efficiently, an individual's body position is automatically adjusted in different situations (e.g. sitting properly in a chair). It also allows one to manipulate objects using fine motor skills, such as writing with a pencil or cutting a paper with scissors. When there is dysfunction in the proprioceptive system individuals appear to be clumsy, have odd body posturing, lack of awareness of body position in relation to space, have difficulty in manipulating small objects and resist new movement activities (Dunn, Myles and Orr, 2002). Another aspect of proprioception is praxis, or motor planning. This is the ability to plan and execute different motor tasks that usually require multiple steps and it will be described in more detail in the following section. In order for proprioception system to work properly, accurate information from the sensory systems must be obtained and then this information must be interpreted efficiently and effectively.

Children with autism frequently show signs of proprioceptive processing difficulties. They usually present poor motor orientation, often walk with an odd gait, can be clumsy, and sometimes have difficulty in adjusting body position as necessary (Dunn, Myles and Orr, 2002). Additionally, children may not obtain sufficient information about body position and body parts and experience difficulty in unconscious body movements, such as siting down or standing up. Furthermore, the proprioceptive system is related to the development of fine and gross motor skills. Children with autism may have difficulty in executing different actions that require these skills, such as holding a pencil or changing body position (Bogdashina, 2003). Problems in the proprioceptive system are usually accompanied by vestibular system difficulties and this may result in insufficient self-awareness. Consequently, the children might lack emotional confidence and feel insecure (Bahr, 2001). For example, Weimer et al. (2001) found that children and adolescents with autism showed similar performance to controls on tests that involved visual input (e.g. finger tapping, inserting pegs into a board). However, they experienced more difficulties on tests without visual input, which required them to depend on proprioception (e.g. repetitive finger-thumb apposition or balancing on one foot with eyes closed). Given the importance of proprioception for even the most basic motor function, directly examining proprioceptive processing in individuals with autism is crucial for understanding the underlying causes of the socio-communicative and sensory-motor difficulties.

2.4.3 Planning skills and autism

The topic of planning has received much attention in recent years, as researchers investigate it in various populations, including autism (e.g. Hughes, 1996; Hill, 2004). Planning seems to be naturally falling under two categories. The first one is referred to as *executive planning*, which categorises planning as an executive function and involves a sequence of moves or choices that have to be arranged in a specific order to reach a goal (van Swieten, et al., 2009). Methods for assessing executive planning include tasks such as the Towers of Hanoi (e.g. Hill, 2004) and London (Shallice, 1982). These tasks require a sequence of abstract thoughts about a goal state, and place demands upon working memory. The second category is referred to as *motor planning* and includes a sequence of simple motor actions to perform a movement, such as grasping (Cohen and Rosenbaum, 2004; Rosenbaum, Heugten, and Caldwell, 1996; Rosenbaum, Meulenbroek and Vaughn, 1996). Praxis is the ability to plan, sequence, and execute novel movements, based upon a foundation of appropriate sensory processing and body awareness (Ayres, 1972, 1979, 2005). This term is often used interchangeably with the term *motor planning*; however, praxis, as conceptualised by Dr J. Ayres, includes the ideation portion of motor planning, in other words the organisation of the self (Ayres, 1972). This is the definition that the researcher also follows. This definition encompasses sensory-motor skills, but also extends to cognitive motor tasks.

Praxis allows individuals to appreciate and carry out motor activities that require multiple steps, as well as make inferences about new tasks based on similar ones already experienced (Ayres, 1972). Most young children demonstrate this ability from an early age, organising their actions with a purpose in mind. For instance, although toys may be on the floor and people may be moving around, most children would be able to physically navigate a busy room without any difficulty. The reason they are able to do this is because they have a motor planning ability. At a certain age they recognise when they should tiptoe carefully and can generally maintain such control over their body. Praxis therefore, is possible through a three-step process: ideation (understanding the task), organisation (planning how to perform the task) and execution (carrying out the task) (Hughes, 1996). This ideation component is cognitively based and interacts with the environmental context and the affordances of the objects and environment to which the child is exposed. Specifically, Dr J. Ayres (1985) stated "praxis is expressed in a manner which is dependent upon the environmental invitation and demand. Praxis is context dependent and the physical environment elicits and determines the idea and the motor planning" (p. 6). It is noteworthy that Dr J. Ayres' definition of praxis is broader than other definitions, which focus primarily on gesture performance (Dewey, 1995). The generally accepted definition does not include the issue of poor sensory processing as potentially causal, as was suggested by Dr J. Ayres. For purposes of the current study, the broader definition of praxis is more fitting.

Difficulties with motor planning, have been repeatedly documented throughout literature related to autism (Rogers, et al., 2003; Mostofsky et al., 2006; Dziuk et al., 2007; Vanvuchelen et al., 2007; Dowell, Mahone and Mostofsky, 2009). Even with the body of literature, reported above, that documents imitation difficulties in autism, some researchers have suggested that no basic imitation deficits exist in individuals with autism, but that motor planning is instead the problem (Hamilton, Brindley and Frith, 2007; Gallese, Rochat, Cossu and Sinigaglia, 2009;). These studies have matched children with autism and typically developing children for verbal mental age and completed a series of experiments to measure goal-directed imitation, mirror imitation, grasp imitation, motor planning and gesture recognition (Hamilton et al., 2007). The participants were first asked to copy an adult, who moved their hand on a table onto a target, which, for some of the trials, was covering a dot on the table. There were no differences between the study groups, however, the children with autism, who did not demonstrate difficulties crossing their own midline, made errors imitating the adult when the adult crossed midline. The children followed the intent of the action (i.e. to touch the dot) rather than the method to complete the action (i.e. use the opposite hand to touch the dot). Dowell et al. (2009) compared performance between 37 individuals with autism and 50 typically developing controls. All children in the sample were between eight and 13 years of age, primarily male and diagnosed with Asperger's syndrome or high functioning autism. Each completed a basic motor-skills assessment, a test of postural knowledge, and a praxis battery. The praxis battery consisted of items that measured praxis from verbal command, in imitation and via gesture with an actual tool. The children with autism performed poorly on all three measures and more poorly on the measures of praxis than the other measures, even after controlling for age, IQ, basic motor skill and postural knowledge. The praxis scores were significantly associated with the scores from the tool used to diagnose autism. Dziuk et al. (2007) attempted to clarify the relationship between basic motor deficits and dyspraxia, which was defined as the impaired performance of skilled gestures. Their sample of 47 young individuals with autism and 47 typically developing controls, aged eight to 14 years of age, completed various motor and praxis assessments. The basic motor measures were related to handedness, gait, balance, and repetitive and timed motion of the arms and hands. The praxis measures addressed gestures to command, gestures to imitation, and gestures with tools. The participating individuals with autism did not perform as well as the controls on the measures of praxis and basic motor control. They also had significantly lower full-scale IQ scores. Whereas Dziuk et al. (2007) found that basic motor skill did predict performance on praxis measures, after accounting for age, IQ, and basic motor skill, individuals with autism continued to demonstrate greater deficits in praxis than the controls. Interestingly, the praxis measures were strongly predictive of features and characteristics of autism used to diagnose and define the condition.

2.5 Relationship with other behaviours

Researchers have consistently found a relationship between sensory-motor processing and other aspects of functioning, such as adaptive behaviour (Lane et al., 2010) repetitive and restricted behaviour (Chen et al., 2009) mental health, quality of life, social interaction and participation and motor skills in individuals with autism (Baranek et al., 1997; Baranek et al., 2006; Gabriels, Agnew, Miller, et al., 2008; Boyd et al., 2009; Jasmin et al., 2009; Boyd et al., 2010; Reynolds et al., 2011; Tseng et al., 2011; Foss-Feig et al., 2012;). Some studies have suggested no relationship between IQ and sensory processing (Leekam et al., 2007). However, sensory processing appears to be a helpful measure in discriminating individuals who may later be diagnosed with autism (Baranek, 1999; Zwaigenbaum et al., 2005; Watson et al., 2007). Smell and taste issues may be particularly discriminating at older ages (Leekam et al., 2007; Schoen et al., 2009; Lane et al., 2010). For the purposes of this study, background information is going to be given about social play and adaptive behaviours, as these were the behaviours the researcher investigated in her study.

2.5.1 Social play and sensory-motor processing

Because the earliest stages of play are both sensory-motor and imitative in nature and begin early in infancy, as body awareness is developed, it is likely that problems in sensory-motor processing could lead to difficulties in play behaviours. However, this has not been well studied. Lower scores were found on a measure of play in children with sensory processing dysfunction, than in children without it (Schoen et al., 2009). However, play preferences were similar between the two groups and many of the individuals with sensory processing dysfunction compensated well, despite poorer motor control (Bundy, 1989; Clifford and Bundy, 1989). A recent study found that children with sensory processing difficulties have poorer scores on play skills, compared to their typically developing peers (Bundy, Shia, Qi and Miller, 2007). Although still relatively playful, those with sensory-motor difficulties tend to engage in solitary rather than active, group play. Honey, Leekam, Turner, and McConachie (2007) used a parent-report measure to examine the relationship between play behaviour, level of play, and repetitive behaviours. Using a 31-item scale developed specifically for their study, the researchers compared 117 typically developing children to 79 children with autism. The children with autism received higher scores, which indicated more repetitive behaviour, and lower scores on play behaviour than the typically developing children. The items used to measure repetitive behaviour, however, could also be considered measures of sensory processing problems. The items addressed unusual interest in smell, special interest in bright, shiny objects, touching parts of the body, spinning and rocking. Few of the scale items did not reference some aspect of sensory processing. Furthermore, two studies that examined the play behaviours of children with autism (Homes and Willoughby, 2005; Macintosh and Dissanayake, 2006) found that these children engaged more in solitary or parallel play, compared to group activities. Also, in their sample description they provided information about sensory processing, and the scores were low suggesting problems in this area. Therefore, perhaps poor sensory processing might be related to problems in play behaviour.

2.5.2 Adaptive behaviour and sensory-motor processing

Researchers have recently become interested in the relationship between sensory-motor processing and adaptive behaviours (Jasmin et al., 2009; O'Donnell et al., 2012). Using the Vineland Adaptive Behavior Scales (VABS; Sparrow, Balla and Cicchetti, 1984), Jasmin and colleagues (2009) explored the relationship between sensory processing and daily living skills in children with autism aged three to four years old. Findings indicated that sensory avoiding was significantly correlated with daily living skills. Children who presented more sensory avoiding behaviours performed worse in daily living activities too. In a more recent study, O'Donnell et al. (2012), administered the Short Sensory Profile (SSP; Dunn, 1999) and the VABS to 39 children with autism and they found strong correlations between severity of sensory processing skills and difficulties in adaptive behaviours overall. Also, different researchers have shown improvements in the adaptive behaviours of children with autism when their sensory processing skills were improved. For example, Silva, Ayres and Schalock (2008), used a Qigong Sensory Training (QST) method for children with autism to discover the impact on their adaptive behaviour. QST is a qigong massage intervention based in Chinese medicine. It is two-pronged in the sense that trainers work with children directly 20 times over 5 months, and parents give the massage daily to their children. Twenty six children, between three and six years old, participated, providing a similar age group to the one that the researcher used. After participating in the intervention, the children scored higher in VABS-II interview based test. Greatest improvements were noted in daily living skills, motor development and communication. In a more recent study, Ajzenman, Standeven and Shurtleff (2013) conducted a pilot study using a single group pre-post-test design, involving a 12-week physical exercise hippotherapy training for children with autism between five and 12 years old. Hippotherapy training is a treatment strategy that uses the horse's movement as a tool to affect functional outcomes. An occupational therapist, physical therapist, or speech–language pathologist continually modifies the horse's movement throughout the session to address clients' needs as they work toward functional goals (American Hippotherapy Association, 2010). Data was collected one week before and one week after completion of the intervention and the researchers saw significant changes in the overall adaptive behaviour composite score. More specifically, they found significant differences in children's communication domain, especially in the receptive sub-domain. They also found significant differences in the socialisation domain, especially in the coping subdomain. However, they did not find significant differences in the daily living skills or motor domain. In both studies researchers found significant improvements in communication, especially the receptive subdomain.

Given the particular ways that children with autism process sensory information, there is a need to understand why these differences emerge and to explain their nature. The most predominant theories that were developed to try to explain autism, are heavily cognitively driven and in that sense they fail to explain the diverse range of characteristics of these individuals and they do not include the sensory aspect of the condition. Below there is a description of the cognitive theories of autism, the reasons they fail to explain every aspect of the condition and new theories that try to fill the existing gap.

2.6 Traditional cognitive theories of autism

Different cognitive theories have been proposed in an effort to understand autism behaviour. These theories include Theory of Mind (Baron-Cohen, 1995), Weak Central Coherence (Frith, 2003) and Weak Executive Functioning (Ozonoff et. al, 1991).

2.6.1 Theory of Mind

Theory of Mind (ToM) refers to the ability to make inferences about others' mental states (e.g. emotions, intentions, beliefs, etc.) (Premack and Woodruff, 1978; Baron-Cohen, 1995). Impaired ToM results in the difficulty to understand and predict other people's behaviours and feelings, which is probably the most common autism characteristic (Baron-Cohen et al., 1995). Despite its early criticism (e.g. Russell, 1992), ToM is often considered the most predominant theory in autism (e.g. Baron-Cohen et al., 1997). However, when adopting this theory fundamental difficulties might arise. Although initial data suggested a preserved level of ToM in individuals with autism (Happe, 1995; Bowler, 2006), ToM as a construct does not reliably differentiate individuals with autism from those with sensory difficulties and intellectual disability (Russell et al., 1998; Yirmiya et al., 1998). Moreover, ToM is thought to be dependent on the capacity for complex thinking and meta-representation (Boucher, 2012), which are heavily reliant on language skills. Therefore, this raises the question of whether ToM is truly impaired in individuals with autism or, by using the impaired language ability as a diagnostic criterion, this level of ToM impairment is naturally inflated (Whyatt and Craig, 2013).

2.6.2 Weak Central Coherence theory

Weak Central Coherence theory (Frith, 2003) refers to a perceptual-cognitive style and suggests that individuals with autism have difficulties with global processing of information, showing instead a preference for local and fragmented level detail (Frith, 2003). More loosely, this is described as a difficulty to 'see the bigger picture'. Studies using visuospatial tasks confirm the theory to a great extent. Individuals with autism performed faster than controls in Block Design tasks, where a figure has to be divided in its constituent blocks (Happe, 1999). They also performed faster in Embedded Figures tasks, in which hidden shapes in drawings have to be found as quickly as possible (Jolliffe and Baron-Cohen, 1997). These results suggest that individuals with autism perform better on low-visual tasks (Happe, 1996). It is very interesting to note that those individuals with autism who scored higher in these tasks, were found to have greater sensory-motor problems compared to the ones who scored lower (Siaperas, 2012). This might be because the visual perception plays an important role in sensory-motor development (Ayres, 1972) and therefore focusing on the detail (e.g. body part, instead of whole body input) leads to greater sensory-motor problems (Siaperas, 2012). However, studies present conflicting findings as to whether weak central coherence theory and visual perception are global autism characteristics (Jarrold and Russel, 1997; Edgin and Pennington, 2005).

2.6.3 Executive functioning theory

Executive functioning consists of higher-order functions that are necessary for regulating and setting goal-oriented behaviours (Pellicano, 2012). These include skills such as organising, planning, sustaining attention and inhibiting inappropriate responses. Individuals with autism commonly show difficulties in the following areas of executive functioning: shifting, inhibition, working memory and planning (South, Ozonoff and Mcmahon, 2007). Shifting refers to the ability to perform a task and then shift to another task. It can also include shifting between different steps within a task. In individuals with autism this is often described as 'difficulty with transitions'. Inhibition, or impulsive control, is an essential element to keep an individual focused on an appropriate task so that the goal can be reached; hence it is a great part of sustained attention. Temple Grandin once said: "I cannot hold one piece of information in my mind while I manipulate the next step in the sequence." (Grandin, 1992a cited in Schopler and Mesibov, 2013 p.145). Working memory refers to the ability to remember all the steps needed to reach a goal (Hill, 2004). For individuals with autism this may be difficult and it may result in difficulties with everyday routines, academic activities and play (South et al., 2007). Executive planning involves a sequence of logical steps or moves to complete a goal. Individuals with autism demonstrate difficulties on tasks requiring planning, such as the Tower of Hanoi (Hill, 2004) and the Tower of London (Shallice, 1982) compared to their typically developing peers.

These theories of autism are focused on the cognitive and perceptive style of individuals (De Jaeger, 2013) and fail to encompass the diverse range of characteristics associated with autism. Also, these complex levels of cognitive functioning emerge from approximately the age of four in typically developing individuals (Boucher, 2012). Therefore, a purely cognitive explanation of autism fails to account for autism characteristics that are present within the first years of an infant's life (Gillberg et al., 1990; Dawson et al., 2000). Different researchers propose that difficulties in sensory-motor development may be the missing link in understanding core elements of autism (De Jaegher, 2013; Whyatt and Craig, 2013). Previous studies have suggested how cognition and sensory-motor abilities develop in parallel and are dependent on each other (Campos et al., 2000; Iverson, 2010). Indeed, evidence of links between cognitive and sensory-motor skills in autism have been documented by Hilton et al. (2007), who found a strong correlation between autism severity, using the social responsiveness scale (Constantino et al., 2003) and sensory-motor difficulties. This mounting evidence suggests that the presence of sensory-motor difficulties in autism is becoming recognised as fundamental in autism (Fournier et al., 2010). This is further supported by the DSM-5 that includes, in the diagnostic criteria for autism, the restricted and repetitive behaviours, which contain hyper- or hypo-reactivity to sensory input, or unusual interest in sensory aspects of the environment (APA, 2013). The theory trying to explain these difficulties in autism is the sensory integration theory that is developed in the next sections.

2.7 Sensory Integration theory

Review of sensory integration

Sensory Integration (SI: often called sensory processing) is a neurological process, which incorporates the ability to process, organise and interpret sensory data from the environment and the body, and respond appropriately (Ayres, 1972). This process examines how individuals develop the ability to organise sensations and select the information that deserves attention or response, in order to perform meaningful activities, and ignore what is not relevant in a specific occasion (Miller, et al. 2007). Sensory integration as a process cannot be observed, as it is taking place in the brain. Instead, one can only look at the product or outcome, which is the behaviour or mood change a child exhibits as he or she is integrating or organising sensory input from the environment (Bundy, et al., 2002). Furthermore, the mechanism of sensory integration continues to develop through the lifetime (Kranowitz, 1998) and this occurs through new activities, experimenting, effort and exploring.

Components of sensory processing include receipt of sensory stimuli by sensory receptors, transmission of those inputs to and through the central nervous system via electrical impulses and chemical transmission, modulation, discrimination/perception, and multisensory integration. Human senses include the systems of touch (tactile), sight (visual), smell (olfactory), taste (gustatory) and sound (auditory). However, there are two more senses that are quite powerful: the vestibular system, which includes balance and motion through space; and proprioception, which includes muscle force and joint position (Dimatties and Sammons, 2003). The outcome of adequate sensory processing is an appropriate motor or behavioural response to input. According to SI theory, effective integration of the input from the senses in the brain allows for optimised performance in reaction to environmental events (Ayres, 1972).

Ayres (1972) defines the sensory integration mechanism at four different levels. *The first level* focuses on the touch stimulus, since it starts when the babies start exploring the environment and receive information through their skin. Through their movement, they start to develop their vestibular and proprioceptive system, including their posture and muscle tone and are able to discriminate and move objects (Bogdashina, 2003). *At the second level*, and after the acquisition of the simple first level sensations, body awareness (body perception) starts to develop. Body awareness is the intellectual ability of body part position and consists of bilateral coordination of the body, hand preference and praxis (motor planning). Any distortion in the perception of the body may lead to insufficient reactions to the environment. *At the third level* the child has developed the ability to use and understand language appropriately. The key aspect of language development and understanding is hearing. Hearing is assisted by the vestibular system, therefore any damage in the vestibular system can result in insufficient language development and/or understanding. Thus, it can be concluded that the sensory integration process is continuous and sustained, in that each level enables the use of the previous one, and any damage in a system affects the development of another (Bogdashina, 2003). *The fourth level* consists of the final product of sensory integration, which is related to academic performance. By the age of six, the child has developed complex motor skills, self-control and social skills. All the senses help in the development of these skills and the child is ready to attend school (Fisher and Murray, 1991; Kranowitz, 1998; Bahr, 2001).

If the child experiences difficulties in developing these skills the intervention strategies of sensory integration involve the use of planned and controlled sensory experiences including, but not limited to, vestibular, proprioceptive, and somatosensory activities, such as swinging, deep pressure touch, and tactile stimulation. The idea of using these types of activities is that they can stimulate several sensory systems at once and gradually introduce children to new sensory experiences and/or help them regulate potential sensory overload (Parham et al., 2007). Also, they are fun to do, as most of these activities are play-based and, although the children do work hard, they also have fun.

History and Development of Sensory Integration Theory

Sensory Integration Theory was developed, over 25 years ago, by an occupational therapist named Dr Jean Ayres. Through this work she hoped to provide a better explanation of the relationship between difficulties in interpreting sensation from the body and the environment, and difficulties related to academic or motor planning (Bundy, et al., 2002). Besides being an occupational therapist, she had advanced training in neuroscience and educational psychology (Dimatties and Sammons, 2003). In 1975, Ayres began to examine the integration of vestibular stimulation, with other sensory input, in adults. She claimed that proximal senses, including vestibular, tactile and proprioceptive, are foundations on which more complex applications are built. While the senses of vision and hearing are critical and become more dominant over time, Ayres believed that more complex skills are built on the proximal senses. Although she published her research, she was heavily criticised for it (Bundy, et al. 2002). The role of proximal senses was a fairly new concept and, up to that time, it was almost ignored by other researchers and clinicians working on child development

(Parham and Mailloux, 1996). Through her research and, after many years of working with sensory assessment, the theory of Sensory Integration (SI) was born. Ayres strongly believed that the results of her research studies provided initial support for her hypothesis, that improving sensory integration through SI intervention resulted in enhanced learning. This was especially the case in children with learning difficulties, sensory integrative dysfunction and those with auditory-language problems. Through the studies she conducted with all these different populations, she reached the conclusion that improving sensory integration resulted in an increase of social, adaptive, academic and generally learning skills (Bundy, et al., 2002). The main hypothesis, for which she was heavily critised, related to the neurological changes she proposed and was unable to explain (Dunn, 1988). She hypothesised that atypical brain development could be counteracted with systematic sensory stimulation, resulting in permanent changes in the brain, which would allow these individuals to process sensory stimuli appropriately, in other words curing them of their difficulties and eliminating their need for sensory-based interventions.

Recent developments in sensory integration

Winnie Dunn (1988) was a student of Dr Jean Ayres who expanded the theory of sensory integration by explaining neurological functions to support it. According to Dunn (1988), every receptor in the central nervous system has a threshold for firing and each threshold can be high, low, or normal. Individuals with high or low sensory thresholds have poor sensory processing skills and, therefore, would present atypical responses to sensory stimuli, as compared to individuals with normal thresholds for sensory stimulation. Additionally, individuals with high thresholds need more stimulation in order to trigger that sensory receptor, whereas individuals with low thresholds need less. Using this theoretical support, Dunn (1997) developed a conceptual model of sensory processing. She hypothesised that individuals with sensory modulation difficulties either had high or low thresholds for sensory stimuli, so that these individuals either acted in accordance with their thresholds or acted to counteract their thresholds. For example, individuals who have very low thresholds for auditory stimulation may cry or scream because the auditory stimulation is uncomfortable. If they were trying to counteract their low thresholds for auditory stimulation they might plug their ears or try to avoid the auditory stimulation all together. Although Dunn's (1997) conceptual model of sensory processing was an extension of Dr J. Ayres' (1972) theory of sensory integration, there were some defining differences between the two. Dunn (1997) stated that an individual's sensory modulation remains fairly stable across the lifespan and that an individual can have high and low thresholds at the same time, within different sensory systems. This view was also supported by other researchers more recently (Bogdashina, 2003; Caldwell, 2008).

Additionally, Winnie Dunn created the Sensory Profile (SP), which is a standardised assessment to measure sensory processing patterns across all of the sensory systems (Dunn, 1999). According to Dunn (2007), a person's sensory processing difficulties are evident, based on the person's behaviour and response to sensory stimulation. Although she based her model of sensory processing on the constructs of the theory of sensory integration, her hypothesis of identifying an individual's sensory processing patterns, based on his or her behaviour, also supports some principles of the theory of optimal arousal. There is a reference on this theory in the next section and how it is related to sensory processing.

2.8 The theory of optimal arousal

The theory of optimal arousal was first introduced by Clarence Leuba in 1955 (Leuba, 1955). Leuba was a professor of psychology who stated that all organisms function best when they are at an optimal level of arousal. He suggested that most organisms were in a state of under-arousal and were striving to increase their stimulation in order to reach an optimal level. Despite this belief, he also speculated that some organisms may achieve a state of over-arousal and that those organisms had to decrease their stimulation in order to reach an optimal level. Leuba's (1955) theory included all organisms and was not specific to humans. Zentall and Zentall (1983) extended the theory of optimal arousal, by specifically applying the theory to humans. They compared populations of individuals with disabilities to those who were developing typically, in terms of their optimal arousal level. They stated that individuals could be above or below their optimal level of arousal and that they would engage in behaviours that would help them reach their optimal level. They noted that individuals with autism reacted in 'typical' environments in the same way that individuals who were developing typically reacted in over or under-stimulating settings. Thus, they concluded that individuals with autism were over or under their optimal level of arousal in 'typical' environments, when individuals without disabilities would be at their optimal level of arousal. They further supported the idea that individuals with autism engaged in stereotypic behaviour in order to increase or decrease their sensory stimulation and achieve their optimal levels of arousal. According to Repp, Karsh, Deitz, and Singh (1992) one of the best ways to determine if a person is above or below his or her optimal level of arousal is by observing his or her level of activity. Individuals who are over-aroused will engage in behaviours to reduce their levels of arousal, such as becoming lethargic, under-responsive or engaging in repetitive calming behaviours.

Individuals who are under-aroused will engage in behaviours to increase their levels of arousal, such as using fast intense movements or appearing hyper-active. Therefore, Zentall and Zentall (1983) and Repp et al. (1992) agreed with Dunn (2007), that an individual's response to sensory stimulation can be determined, based on his or her behavioural response to that stimulation.

Although Dunn (1997) developed her model to align with the theory of sensory integration, her conceptual model is applicable to the theory of optimal arousal. Her model was based on behavioural responses to sensory stimulation and she hypothesised that, although there can be variability with an individual's sensory processing abilities over time, based on the environment, amount of sleep, hunger, and so forth, overall sensory processing difficulties are persistent across the lifespan (Dunn, 1997, 2007), which are also the basic tenets of the theory of optimal arousal. The theory of optimal arousal has more empirical support in the field of autism than the theory of sensory integration. Several researchers have documented that sensory processing difficulties are persistent across the lifespan of individuals with autism (Bogdashina, 2003; Kern et al., 2006; Minshew and Hobson, 2008). Thus, individuals with autism continue to have difficulty processing sensory stimuli and these difficulties do not go away over time, rejecting the permanent changes in the brain as hypothesised by Dr J. Ayres (1972). Researchers have documented that younger individuals with more severe autism characteristics have more difficulty with sensory processing than older individuals with autism, although older individuals with autism (regardless of severity) still have atypical sensory processing abilities as compared to typical peers (Kern, Trivedi, et al., 2007).

2.9 Motion-based learning theory

The previous sections examined different theories that try to explain sensory processing in autism. Here, the researcher examines the possibility of motion-based games in learning and their relationship to sensory-motor development. She will try to build on the gamification or gaming theory (Kim, 2014; McGonigal, 2011) and motion-based interaction. This is important to explore, as the researcher used Pictogram Room as the intervention tool for sensory-motor development, which is a technology that uses the body input to control the environment and complete the games.

The potential of motion-based interaction for learning is grounded on theoretical approaches that recognise the relationship between physical activity and cognitive processes, and are supported by a growing body of evidence from psychology and neurobiology. Piaget’s theory states that knowledge acquisition arises from active experiences in the world. Embodied cognition theory emphasises the formative role of embodiment, which is the way in which an individual’s sensory-motor capacities enable him or her to successfully interact with the physical environment (Eigsti, 2013). The cognitive processes linked to mastering sensory-motor contingencies originate from embodied experiences, but also some higher-level cognitive skills, such as mental imagery, working memory, implicit memory, reasoning and problem solving, arise from sensory-motor functions (Eigsti, 2013). Embodied cognition provides a theoretical underpinning for the educational potential of touchless motion-based games (Kim et al., 2014).

This hypothesis is also supported by the results of empirical studies that include both typically developing population and participants with autism. Much work has focused on creating movement-like experiences to help fight sedentary lifestyles among younger audiences (Consolvo et al., 2006) or healthy lifestyle and motivation for the elderly (Baalam et al., 2011). Kynigos et al. (2010) in their study with typically developing children, presented a set of collaborative full-body digital games designed to understand what meanings learners develop during body-movement and gestures. Authors reported that children perceived body motion as a natural way to interact and mutually communicate, and directly connected their body actions with the mathematical concepts embedded in the games. Additionally, Bartoli et al. (2013) conducted a study with five children with autism, using a set of motion-based touchless video games to investigate the relationship between body involvement and engagement in educational motion-based gaming. The study revealed that an increase in body movement resulted in an increase in the player's engagement level, attention and positive emotional response. Furthermore, Blum-Dimaya et al. (2010) used a commercial Wii video game and extended with video modeling capabilities to give the opportunity to children with autism to develop imitative skills during, rather than after, the streaming video footage. The four participants in the evaluation successfully learned to play the game and playing skills generalised to different video-game settings. The two big platforms that allow motion-based touchless gaming are the Xbox 360/Microsoft Kinect and the Nintendo Wii, which are going to be explored in more details in the next chapter.

2.10 Summary

In this chapter, the researcher reviewed the literature regarding the development of sensory-motor skills in typically developing individuals, to provide a context for the development of these skills in autism. The main focus in this study is on vestibular and proprioceptive processing skills, as they are considered among the main sensory modalities for movement in relation to sensory response, yet are quite neglected in the literature. The researcher also took into account planning skills which, according to SI theory, include the ideation portion, in other words the organization of self, which also has a cognitive element required to carry out every day movement tasks. This chapter also addressed the relationship of sensory-motor skills with other behaviours, such as adaptive behaviour, play and social skills. Additionally, the researcher explained why the traditional cognitive theories of autism might fail to explain all the range of difficulties that these individuals might encounter, and the need for a new theoretical model. Therefore, there was a presentation on Sensory Integration theory, its criticisms and the links that it has with the theory of optimal arousal. The chapter concluded with making reference to theories that constitute motion-based touchless learning, mainly through the use of new technologies.

CHAPTER 3

LITERATURE REVIEW: INTERVENTIONS FOR SENSORY-MOTOR DEVELOPMENT

3.1 Introduction

Despite the wide recognition of sensory-motor problems and their effects on participation in different activities for individuals with autism, sensory interventions that tackle sensory-motor skills have been inconsistently defined and refer to widely varied practices. Thus, in this second literature review chapter the researcher tries to cover different interventions that are being used for sensory-motor intervention in autism, including occupational therapy, Sensory Integration therapy, Sensory Integration-Based approaches and physical exercise. Therefore, this chapter starts by describing existing approaches for sensory-motor development in autism. It then discusses the effectiveness of these interventions. It also makes reference to a new approach that has started to be used in recent years, which is technology. Therefore, this chapter also presents game-based learning for children with autism, as well as the use of serious games and augmented reality. Serious games make reference to games that, besides being fun, also promote learning and are used for educational purposes (Deterding et. al, 2011). Augmented reality is a variation of virtual reality, as it combines virtual elements with the real world (Trojan et al., 2013). Finally, there is a reference to two new technological platforms that allow whole body input for the manipulation of the environment, which are the Nintendo Wii and Microsoft Kinect. These are all important aspects, as they support the researcher's decision to use technology as the intervention tool for this study.

3.2 Approaches for sensory-motor integration

Despite the high prevalence of sensory-motor processing issues in individuals with autism, relatively little systematic research has been done on the effectiveness of different interventions. The most widely known and widely used interventions include traditional occupational therapy, sensory integration therapy (Ayres, 1972, 1979), other sensory integration-based approaches, and auditory integration therapy, developed by Berard and Tomatis (Berard, 1993). Auditory integration therapy will not be described in detail, as it is not used for the particular sensory-motor skills that the researcher is targeting for the purposes of this study. It is important to note that occupational therapy has formed the basis of practice in applying different techniques for sensory-motor development (Radomski and Latham, 2008). Hence, before moving to its practice and the way in which it has utilised different frameworks, such as sensory integration therapy, it is important to define the work of occupational therapists. Also, as the current study takes place in a school setting and is targeting the development of sensory-motor skills, there is a more school-based focus for their practice. Finally, physical exercise has also been used for the development of sensory-motor skills and is included in the different approaches. Below, there is a description of the interventions used so far to target sensory-motor skills in autism.

3.2.1 Traditional Occupational Therapy

Occupational therapists study human growth and development and a person's interaction with the environment through daily activities. They are experts in the social, emotional and physiological effects of different conditions and injury. This knowledge helps them promote skills for independent living in people with autism and other developmental disorders. Their work involves a range of planned activities designed to promote the development of skills in the context of work, play, and adaptive behaviour (Radomski and Latham, 2008). Occupational therapists work as part of a team that includes parents, teachers and other professionals. They help set specific goals for the person with autism. These goals often involve sensory-motor development, social interaction, adaptive behaviour and classroom performance. Occupational therapy usually involves two main types of interaction with the individual receiving the therapy; evaluation and actual therapy. Although, the work of occupational therapists described here refers to practices applied in the United Kingdom, nonetheless they are, to a great extent, similar to those that occupational therapists apply across different countries in Europe and in the United States of America (USA).

3.2.1.1 Occupational therapy for evaluation in autism

The occupational therapist observes children to see if they can do expected tasks, depending on their age level (e.g. getting dressed or playing a game). Sometimes, the therapist will have the child videotaped during the day, in order to see how the child interacts with his or her environment, and so that they can better assess the kind of care that the child needs (Schaaf and Miller, 2005). Also, he or she might use standardised or other types of assessment to define the children's needs and ascertain whether they will actually need occupational therapy. Among other behaviours, the therapist might note attention span and stamina, transition to new activities, play skills, need for personal space, responses to touch or other types of stimuli, skills such as posture, balance, or manipulation of small objects, aggression or other types of behaviours that might cause concern and interactions between the child and caregivers or with other children (Radomski and Latham, 2008). It is important to note that evaluation, depending on the setting in which it is taking place, may have different forms. For example, if evaluation takes place in a private office where the occupational therapist works, he or she might be the only one giving feedback to the client or the caregiver. However, most commonly, occupational therapists work as part of a multidisciplinary team. Again, depending on the setting, this team varies. For example, in a hospital setting the occupational therapists might work closely with nurses, doctors and clinical or health psychologists, whereas in a school setting they would work closely with teachers, speech and language therapists and educational psychologists.

3.2.1.2 Occupational therapy for intervention in autism

Once the occupational therapist has gathered information, he or she can develop a programme for the child. There is no single ideal intervention, or programme as it is called in occupational therapy, but early, structured, individualised care has been shown to work best (Schaaf and Miller, 2005). Occupational therapy may combine a variety of strategies. These can help the child respond better to his or her environment. These occupational therapy strategies may include: physical activities, such as stringing beads or doing puzzles, to help a child develop coordination and body awareness, play activities to help with interaction and communication, developmental activities, such as brushing teeth and combing hair and adaptive strategies, such as coping with transitions (Chu, 1997; Radomski and Latham, 2008). The overall goal of occupational therapy is to help individuals with autism improve their quality of life at home and in school, and help them be as independent as possible. Most studies that have explored occupational therapy in autism have focused on the sensory-motor skills needed for academic performance, such as handwriting skills (Oliver, 1990; Chu, 1997; Denton et al., 2006). Within the field of occupational therapy, one of the most commonly used frameworks for autism sensory-motor skills intervention is Sensory Integration therapy, developed by Dr J. Ayers (Ayers, 1972). In fact, one survey found that 99% of occupational therapists working with children with autism spectrum disorders reported using a sensory integration framework (Watling, Deitz, Kanny and McLaughlin, 1999). According to sensory integration theory, problems with sensory perception and integration interfere with the ability to attend and respond appropriately to complex stimuli in the environment, making organised behaviour difficult. The next section describes this therapy in detail.

3.2.2 Sensory Integration therapy

Sensory Integration (SI) therapy includes child-directed activities and sensory-enhanced interactions, emphasising the production of functional and adaptive responses to sensory stimuli. Usually it is provided on a one-to-one basis by a trained occupational therapist. The ultimate goal of SI therapy is to increase the child's ability to integrate sensory information that, in turn, leads to demonstrations of more organised and adaptive behaviours and increased social and joint attention skills (Baranek, 2002). This is mainly achieved through the use of gross motor activities that activate the vestibular and somatosensory systems (Mailloux and Roley, 2010). The therapist designs a skill challenge, which is usually an activity that requires the highest developmental skills from the child's repertoire of emerging skills, and supports the child's adaptive response to the challenge (Watling et al., 2011).

Traditional SI therapy is provided in a clinic or in an environment with specially designed equipment (e.g. swings, therapy balls, trampolines and climbing walls) that can provide vestibular and proprioceptive stimulation using playful, goal-directed activities. To ensure fidelity of implementation of clinic-based SI therapy, ten essential elements have been defined (Parham et al., 2007, 2011). Each element is individualised to the child's needs and targets specific objectives. The essential elements are as follows: (a) ensuring safety, (b) presenting a range of sensory opportunities (specifically tactile, proprioceptive, and vestibular), (c) using activity and arranging the environment to help the child maintain self-regulation and alertness, (d) challenging postural, ocular, oral, or bilateral motor control, (e) challenging praxis and organisation of behaviour, (f) collaborating with the child on activity choices, (g) tailoring activities to present the "just-right challenge," (h) ensuring that activities are successful, (i) supporting the child's intrinsic motivation to play, and (j) establishing an intervention alliance with the child (Parham et al., 2007, 2011). In addition to working directly with the child, the therapist reframes the child's behaviours to the parent or clinician using a sensory processing perspective (Bundy, 2002; Parham and Mailloux, 2010). Explaining the possible links between sensory processing and challenging behaviours, strategies that target the child's hyper- or hypo-reactivity, are recommended so that they can help caregivers and other treatment providers develop different approaches to accommodate the child's needs. By modifying the child's environment or routines to support self-regulation, the child can more fully participate in everyday activities. Recommended modifications to the child's daily routines or environments often promote a balance of lively and quiet activities, and provide opportunities for the child to participate in preferred sensory experiences (e.g.

swinging in the backyard or neighbourhood playground, climbing on a gym set, supervised trampoline jumping and quiet rhythmic rocking in a low lit bedroom).

The sessions are delivered approximately one to three times per week and last for about an hour. The duration of the whole treatment program may last from several months to some years. The therapist creates activities that help the child to engage and participate, challenging his or her sensory processing and motor planning skills (Ayres, 1972; Parham and Mailloux, 2010). Along with the treatment, consulting services are provided to family or school about different tasks. Although the equipment is generally low-tech, it can be very expensive. For all these reasons, but especially because of the specialised equipment and the "pull-out" sessions, Sensory Integration therapy is not very feasible for a school environment (Pfeiffer, Koenig, Kinnealey, Sheppard and Henderson, 2011).

3.2.3 Other Sensory Integration-Based Approaches

Various interventions based on sensory integration have been documented, but they differ in one or more criteria. One of the main differences is that, although the intervention is still one-to-one or in a group basis, the approaches used are more adult-directed rather than child-directed. The activities used are intended to fit the child's everyday routine but require less engagement from his or her side (Case-Smith et al., 2014). Furthermore, although somatosensory and vestibular activities are provided, no suspended equipment is being used. Also, many of these activities or approaches, such as weighted vests, brushing, bouncing on a ball, are used in the child's natural environment rather than a clinic and are not necessarily provided by an occupational therapist but instead by a family member, teacher or another practitioner

(Wilbarger, 2002). Examples of other approaches and activities within the sensory integration based paradigm include the “Sensory Diet” and the “Alert Program” (Williams and Shellenberger, 1996). In “Sensory Diet” (Wilbarger, 2002) the child is provided with a home or classroom program of sensory-based activities aimed at fulfilling his or her sensory needs. A schedule of frequent and systematically applied somatosensory stimulation (i.e., brushing with a surgical brush and joint compressions) is followed by a prescribed set of activities which are designed to meet the child’s sensory needs and integrated into the child’s daily routine. “Alert Program,” melds together aspects of sensory integration theory with a cognitive-behavioral approach. It is very similar to “Sensory Diet” but in this approach the child usually has a higher functioning level and verbal abilities and is given additional cognitive strategies to assist with his or her arousal modulation.

Sensory integration-based approaches, like sensory integration approaches, are based on neuroscience models (e.g. Kandel et al., 2000; Lane, 2002) and clinical observations (Mailloux and Roley, 2010). They support the theory that certain types of sensory input, for example, deep touch and rocking, are calming, and that rhythmic application of touch (e.g. brushing) or vestibular sensation (e.g. linear swinging) has an organising effect that promotes self-regulation (Ayres, 1979; Parham and Mailloux, 2010). However, although these interventions are based on SI theory, they also focus extensively on the theory of arousal. They are based on the hypothesis that the efficiency with which the child’s nervous system interprets and uses sensory information can be enhanced through systematic application of sensation, in order to promote change in arousal state (Parham and Mailloux, 2010). A key feature of these techniques is that they are designed to influence the child’s state of arousal, most often to lower a high arousal state such as agitation, hyper-activity or self-stimulating behaviours (Case-Smith et al., 2014).

3.2.4 Physical Exercise

Physical exercise is any bodily activity that individuals do that enhances or maintains physical fitness, health and wellness (Buckley et al., 2015). People exercise for various reasons including health, fitness or weight loss but also just for fun. Benefits of exercise include changes in well-being as well as changes that concern physical strength. Additionally, it has an effect on maladaptive and self-stimulatory behaviour, stress and hyper- or hypo-active behaviour (Lang et al., 2010). In general, physical exercise is beneficial for every individual and previous research has demonstrated positive outcomes for typically developing individuals (Fedewa and Ahn, 2011; Penedo and Dahn, 2005). Despite the growing evidence of physical exercise benefits for the typically developing population, there is still limited research on the benefits for individuals with autism, especially younger children (Bremer et al., 2016). But it can also be of particular importance to include physical exercise in training programmes for children with autism. The movement experiences, through exercise, provide children with essential information of their own body awareness, as well as recognising the environment (Lang et al., 2010). Also, movement training can be useful for improving the children's ability to solve problems that often require multiple and complex steps, expressing themselves and seeking creative solutions to problems. Movement training can also be used to develop skills such as attention, focusing and engaging. Moreover, the emotional and social gains acquired through exercise are crucial for daily life and help children with autism to act in coordination with other children and participate more in collaborative activities (Eichstaedt and

Lavay, 1992). Its importance can also be apparent by the fact that it is part of many regular education curricula and many schools have a gym area (Pate et al., 2006). Usually the people delivering physical exercise in school settings are the physical education teachers, who are trained in sports science. The instruction during physical exercise classes is provided mostly in groups, but also on an individual level. The cost of providing services is minimal provided that there is enough space. Physical exercise has also being linked with changes that are related to a more neurochemical point of view. The results of a number of studies indicate that physical exercise improves synthesis and metabolism of oxytocin (Hew-Butler, Noakes, Soldin, and Verbalis, 2008), as well as synthesis and metabolism of serotonin (Meeusen and Meirleir, 1995). This is very important as neurotransmitters like serotonin and oxytocin have been found to be atypical in individuals with autism (Chandane, 2005; Bean, 2006) and are related to social skills performance (Mier, Kirsch and Meyer-Lindenberg, 2010). Thus, one could speculate that physical exercise can contribute to the increase of oxytocin and serotonin levels which, in turn, can assist in social skills development (Fazlioglu and Baran, 2008).

3.3 Efficacy of sensory-motor interventions for children with autism

As mentioned previously, Sensory Integration therapy is the most common practice within occupational therapy for individuals with autism. However, as discussed, there are some other types of approaches followed for the development of the sensory-motor skills of children with autism, such as other sensory integration-based approaches and physical exercise. It is crucial, therefore, to evaluate the effectiveness of all these interventions, as well as suggesting why they might be or might not be effective. The following sections investigate the effectiveness of the above interventions. As sensory integration therapy and sensory integration-based approaches are built mainly on the principles of sensory integration theory, with the sensory integration-based approaches also drawing elements from the theory of arousal, they are examined together. Following this is a section regarding the evaluation of physical exercise.

3.3.1 Efficacy of occupational therapy, Sensory Integration therapy and Sensory Integration-Based approaches

There are four big systematic reviews that have been conducted so far to test the effectiveness of occupational therapy, Sensory Integration therapy and Sensory Integration-Based approaches in children with autism. More specifically, these reviews examined sensory and motor interventions (Baranek, 2002), occupational therapy interventions (Case-Smith and Arbesman, 2008), SIB approaches (Lang et al., 2012), SI therapy and SIB approaches (Case-Smith et al., 2014). The former two have defined SI therapy and SIB broadly, including auditory integration therapy, which is excluded for the purposes of the researcher's study. Using this broader definition, Baranek (2002) and Case-Smith and Arbesman (2008) concluded that evidence on the efficacy of these approaches was uncertain, with low level evidence that their application improved social interaction, social play and reduced hyper-reactivity in children with autism. They also presented with methodological constraints, as they used convenience sample, observer bias and not well-defined control groups (Baranek, 2002; Case-Smith and Arbesman, 2008). These researchers suggested that future studies on these approaches should focus on more functional outcomes, in addition to sensory processing measures and also link physiological measures to these outcomes (e.g. heart-rate response and electrodermal activity). Finally, they recommended future studies should include long-term outcomes. Land et al. (2012) in his review evaluated 25 studies of Sensory Integration therapy (n=5) and Sensory Integration-Based approaches (n=20). The results of this review were consistent with the two reviews mentioned previously, in that their majority revealed “suggestive” findings. This was mainly because 19 of these studies used single-subject design approaches (Case-Smith et al., 2014). The most recent review, that of Case-Smith et al. (2014), focused on interventions that activated the somatosensory and vestibular systems. It also differentiated SI therapy, based on the work of Ayres (1972) and manualised by Parham et al. (2011) and SIB approaches that apply specific types of sensory input and are hypothesised to effect self-regulation. Also, unlike the review conducted by Lang et al. (2012) they included only studies where the participants had evidence of sensory processing difficulties. Thus, they identified five studies that used SI therapy and 14 studies that used SIB approaches. Of the SI therapy studies, two randomised control trials showed positive effects on the goal attainment scale (effect sizes were 0.72-1.17) but overall the results were mixed. From the 14 SIB approaches, 13 were single-subject designs, for which it can be argued that there were methodological flaws, with only three studies showing strong effects. One was a study on weighted vests (Fertel-Daly et al., 2001), another on therapy balls (Van Rie and Heflin, 2009) and a third using a multisensory stimulation (Fazlioglu and Baran, 2008). However, these three studies had some methodological limitations that included lack of blinded evaluation, no fidelity of implementation, limited description of the intervention, small sample sizes or not well-defined control groups and only the use of a non-standardised assessment method. Finally, all SIB approaches but one (Davis et al., 2011) took place in schools or educational centres.

Overall findings show that SI therapy has mixed results but there is some evidence that it can be effective, especially when it is tailored to children's needs and there is fidelity of implementation (Parham et al., 2007). Also, it is suggested that these mixed results might be due the fact that when SI therapy is implemented for a research study it is not combined with other strategies or interventions that target behavioural, life or motor skills, which is usually the case in every day practice (Case-Smith et al., 2014). For example, Phoebe Caldwell (2008) published a book about the combination of sensory integration with intensive interaction, which is an approach for enabling social communication skills through a caregiver-child interaction (Nind and Hewett, 1994, 2001; Caldwell, 2008). In her book she suggested that the skills targeted by these two interventions can be further developed when they are implemented in combination and, overall, both interventions can be more effective. Not enough evidence exists about the efficacy of the SIB approaches. Also, there are many methodological flaws in the studies that implemented SIB approaches. These two reasons, prevent the recommendation of their use, even if the authors presented positive results in their studies. This was also a conclusion by Case-Smith et al. (2014) in their review. They suggested that this might be the case because SI therapy is provided in a structured environment (i.e. clinic), whereas SIB approaches are usually conducted in school environments. However, they make the assumption that SIB approaches were ineffective because they could be implemented by adults without the necessary training. In addition, there might be a misunderstanding of how and for whom the sensory strategies would be beneficial, and also that there might be a mismatch between the children's needs and what is actually being targeted. This is a very important point that the authors make, as it is related to the collaboration of different disciplines to better identify student's needs.

3.3.2 Efficacy of physical exercise

Five reviews that examined the impact of physical exercise for individuals with autism were retrieved (Petrus et al., 2008; Lang et al., 2010; Sowa and Meulenbroek, 2012; Sorensen and Zarrett, 2014; Bremer et al., 2016). All of these reviews have reported positive outcomes for these individuals. Firstly, in their review Petrus et al. (2008) examined the impact of exercise on individuals with autism, from four to 15 years of age, in relation to their stereotypical behaviours. They identified seven papers that showed moderate to strong effects, four of them used a single-subject approach, two used group design and one was a case study. They also identified that the interventions followed in those studies were not clearly defined. Lang et al. (2010) and Sowa and Meulenbroek (2012), evaluated interventions for a very big age range, including children and adults with autism up to 41 years old, and they found benefits across all studies and ages. Sorensen and Zarrett (2014) focused their review on the benefits of physical exercise for adolescents with autism, but mainly in relation to medical health, rather than behavioural or motor outcomes. The most recent review, that of Bremer et al. (2016) included participants of up to 16 years of age and they found 13 papers that fitted their criteria. They focused only on behavioural outcomes of physical exercise for individuals with autism and they found positive outcomes. However, all these reviews share some common limitations. The interventions they included in their reviews varied significantly, ranging from simple jogging (Rosenthal-Malek et al., 1997), which did not require specific and extensive instructions, to horse riding (Bass et al., 2009) which required implementation by a well-trained individual. Also, the interventions varied in frequency and intensity, so it was hard to make overall conclusions. Additionally, it is very hard to generalise physical exercise findings in one age group, given that two of these reviews (Lang et al., 2010; Sowa and Meulenbroek,

2012) evaluated studies where participants ranged from very young children to older adults. Finally, all of the authors in their reviews suggested the lack of follow-up studies was the biggest limitation, as well as the small number of participants. This could be because all the interventions took place in a natural environment (e.g. gym space). It has been consistently noted that in those environments it is much harder to control for a great number of variables, having large samples or very rigorous experimental designs, such as randomised control trials (Case-Smith et al., 2014).

The number of studies focusing specifically on physical exercise and sensory skills is very limited. Most of the past studies that targeted sensory issues focused on the effects of exercise on self-stimulatory behaviours, and mostly on stereotypical behaviours (e.g. Levinson and Reid, 1993; Elliot, Dobbin, Rose and Soper, 1994; Oriel et al., 2011; Bahrami et al., 2012) with positive results. More recently, there have been studies that looked overall at the sensory processing behaviours, including balance, body awareness and motor planning, that the researcher is investigating for this study as well. These studies included swimming intervention (Yilmaz et al, 2004), skating (Casey et al., 2015) and horse riding (Bass, Llabre and Duchowny, 2009; Kern et al., 2011; Ward et al., 2013). The first two studies had one and two participants respectively and they focused to a great extent on balance skills. They both showed that children's balance skills were significantly improved after the implementation of the interventions. Although the studies on horse riding did focus on social-emotional development, adaptive skills and social participation, they also evaluated sensory processing skills. Bass et al. (2009) conducted a waitlist control group design (interventions group n=19 and control group n=15) with the intervention being one hour per week for 12 weeks. Participants were four-10 years old and their sensory skills were assessed using the Sensory Profile (Dunn, 1999), with the score being significantly improved for the intervention group ($t(18)=-7.29$, $p<0.01$ but not for the control ($t(13)=-1.77$, $p=0.101$). Ward et al. (2013) implemented horse riding with 21 children with autism aged five–10 years old, following an interrupted intervention design; one session per week for the following schedule: six weeks on, six weeks off, four weeks on, six weeks off and eight weeks on for 45–60min per session. Using the Sensory Profile School Companion (Dunn, 2006), they found statistically significant differences ($p<0.01$) across all sensory aspects in the participants before and after the intervention. Unlike these two studies, the study by Kern et al. (2011) showed different results. They conducted a single-subject design with 20 participants completing all stages of the intervention aged between three and 12 years old. Although they carried out their intervention for a longer period than the other two studies (one session per week, one hour a session for six months), they did not find significant differences in children's Sensory Profile scores before and after the intervention. It is important to note that the authors pointed out that the participants were too diverse, in terms of their sensory needs, and as they did not adjust the intervention according to these needs, this might be why they did not have significant differences pre and post intervention.

So far, interventions concerning the development of sensory-motor skills in children with autism could be grouped under three main categories: occupational therapy following the SI therapy, SIB approaches and physical exercise activities. Although they have mixed results, they have been widely used for the development of the aforementioned skills. However, most of them require trained personnel (e.g. occupational therapists or physical education teachers), and in cases where interventions have been implemented by non-specialised personnel, such as in SIB approaches, there were no changes in children's skills. In addition, all of these interventions require special equipment that is usually expensive, or they require use of a specialised location, which again can increase the cost. Also, particularly in the physical exercise studies, the participants' sensory needs were not well specified and, therefore, the activities were not always tailored to their needs. Additionally, in these studies there was a huge variation in the types of activities used, ranging from jogging to skating and horse riding, making the results too varied. Therefore, there is a need for interventions that can be school-based, easily implemented in the classroom by the classroom teachers and can be tailored to each child's needs. It is important, therefore, to find new ways of helping children with their sensory-motor skills development, using alternative methods that would either complement existing intervention programmes they follow, or that would work independently. One innovative way that provides new solutions and gives further opportunities is the use of technology and it is described in the next sections.

3.4 Technology interventions and autism

The development of technology interventions for autism is a relatively new area of research, yet it is fast growing. Several studies have investigated diverse applications of technology with children on the autism spectrum that can be manipulated through different modalities such as touch, voice, motion and text. This increased interest in the use of technology to teach different skills to children with autism is mostly motivated by the notion that these children have a natural affinity for it (Hardy, Ogden, Newman and Cooper, 2002). Several studies have demonstrated that different technologies and software are well received by children with autism. There are multiple reasons for this and research around this subject suggests that technology can offer a predictable and safe environment for students with autism to work in (Battocchi et al., 2008; Putnam and Chong, 2008). Moreover, training through technology eliminates the social complexities of interaction with others that can cause anxiety to these students (Bosseler and Massaro, 2003; Parsons et al., 2009; Parsons and Mitchell, 2002). In addition, tasks can be repeated and students given the opportunity to cope with little change and correct their mistakes (Dautenhahn, 2000; Lanyi and Tilinger, 2004). Furthermore, technology can be personalised to meet the individual needs of the each student. Finally, it's an affordable easily used means for one to one support (Millen, Cobb and Patel, 2011).

Technology interventions have many forms, such as computer-based, video, virtual-reality, small devices and robotics. Computer-based interventions are perhaps the most studied technology-based intervention for children with autism. Computer software (on laptops, desktops or small devices, such as phones or iPads) has been used for the development of different skills, including social skills (e.g. Hetzroni and Tannous, 2004), recognition of emotions (Baron-Cohen, Golan, Wheelwright and Hill, 2004), academic skills (e.g. Bosseler and Massaro, 2003), imitation (e.g. Dautenhahn and Werry, 2004). However, there are hardly any empirical studies using technology-based interventions for the development of sensory-motor skills in children with autism. As mentioned previously, most of the studies conducted in this area looked at the application of Sensory Integration Therapy, occupational therapy and exercise. Most of these interventions are conducted mainly by occupational therapists or other trained staff, such as physical education specialists, and require a specific room and equipment. Therefore, it is of great importance for the teacher to be able to have the means available to support the students in the classroom and help them to develop their motor skills. For this purpose, a technology-based intervention was utilised, called Pictogram Room. Pictogram Room is a serious game platform that uses augmented reality to combine virtual and physical objects, offering the potential for the participant to manipulate the environment with body movement through a camera input. Pictogram Room will be described in detail in the methodology chapter, but it is crucial to mention here how computer games can contribute to learning and the use of what are called serious games. Also, the term augmented reality is going to be explained, along with the benefits of using motion-based touchless technologies, as the researcher did in this study.

3.5 Computer games in learning

Game-based learning (GBL) refers to different kinds of software applications that use games for learning and/or educational purposes. This type of game application is also referred to as serious games (Noor et al., 2012). The main characteristic of an educational computer game is the fact that learning content is blurred with gaming characteristics. The serious games provide ways to individualise and differentiate learning and also to enhance communication between students and teachers. Usually the game based environments are used in more informal contexts (e.g. home), but there is an increasing interest in incorporating them into more formal contexts (e.g. educational context). This holds benefits for both students and teachers.

It is argued that game-based learning can revolutionise students' learning, enhancing their motivation and engaging them in a way that sometimes traditional educational methods may not be able to do (Tobias, Fletcher and Wind, 2014). Several aspects of students' learning are supported when using computer games. They need to draw knowledge from different areas, put this knowledge together to make decisions or actions, they can then test the outcome of the decision or the action they performed and lastly, but more importantly, they have the chance to interact with other students or adults within this process, enhancing their social skills (Moore, McGrath and Thorpe, 2000; Boutsika, 2014). One other great advantage that computer games offer is the opportunity for interactive play. This means that students can receive feedback about their actions and have the opportunity to repeat the process as many times as they want, in order to learn from their mistakes (Noor et al., 2012). In that sense, students have the opportunity to improve themselves constantly, something that traditional educational methods cannot always offer. This, in turn, can offer teachers more time as students can work more independently in these environments. Students also enjoy playing computer games because they help to set long-term goals (e.g. win the game, complete the activity), in addition to offering rewards (e.g. scores, prizes etc.).

Teachers have to create a learning culture that is more in line with students' interests and learning styles. They also need to create learning environments that can actively involve students in the process, enable them to understand the complexity of different situations and assist them in solving problems (Noor et al., 2012). Teachers have available several categories of computer games to choose from. Examples include: action games, adventures games, simulation games, puzzler games, role-playing games, sport games and strategic games. Whatever type of game is chosen, it is important to bear in mind that a game can facilitate the flow experience, if the challenges that the game offers are up to par with the skills of the player. If a game does not provide enough challenge, the player eventually gets bored. If a game provides too much challenge, the player might experience anxiety or quit after endless defeats. If the challenges of a game are equal to the player's skills, the player enters a state of flow (Chen, 2007). Research has consistently shown that playing computer games increases reaction times, improves hand-eye co-ordination and raises players' self-esteem (Rosas et al, 2003). Studies suggest that important skills such as communication and collaboration (e.g. Bailey et al, 2006) may be built or reinforced by video games, through their capacity to offer a more social approach to learning and collaboration.

3.6 Serious games and autism

Currently, numerous studies on serious games for children with autism have been conducted. They are amongst the most exciting technologies, as they combine the potential of technology per se with the educational effectiveness of game-play (Deterding et. al, 2011). Serious games are usually designed, not only for pure entertainment, fun or enjoyment but also, especially in the case of autism, to cover matters related to communication, education, social skills and motor development (McCallum, 2012). Game play is one of the areas of development that can be significantly affected in autism, due to these children's cognitive and emotional difficulties (Bartoli et al., 2013). Integrating digital play (i.e. serious games) in educational routines offers opportunities for developing communication and imagination, as well as encouraging social interactions and increasing the children's ability to perform more effectively in daily tasks (Mader, Natkin and Levieux, 2012). Even in cases where the behaviour can be considered "problematic", such as repetitive behaviour and selective attention, these manifestations can be beneficial when using video gaming as an intervention method (Corbett, 2003). Another aspect, which accounts for the use of game-methods within autism intervention, is that these methods show strongly increased motivation in children with autism (Murray, 1997).

Video games have been used to help develop a range of different skills in children, adolescents and adults of various levels of cognitive abilities and conditions. Among these populations video games have also been used for individuals with autism, and in the last few years they have gained increasing popularity (Demarest, 2000; Whyte, 2015). Although there are many studies that use serious games for intervention in autism, no general review had been conducted. Recently, such a review was published (Ern, 2014). It was a systematic review looking into four big databases; PsychInfo, SciVerse Scopus, ScienceDirect and Web of Knowledge, with the main focus not being simply to see different types of technologies and how they are used for autism, but specifically technology game-like interventions. The search identified 4556 papers, but after careful screening using the inclusion and exclusion criteria, 14 studies were analysed in depth. One of the main targets of this review was to see which skill types these serious-games were targeted at.

Most of the studies that utilised serious games for autism focused on social communication skills (cf. De Silva, Higashi, Lambacher and Osano, 2007). However, there were also a large number of papers regarding facial recognition (cf. Orvalho, Miranda and Sousa, 2009), which, in turn, helps social communication development. This finding is reasonable, as social communication is probably the key issue in autism diagnosis (Hassan et. al, 2011) and it makes sense that most interventions focused on the development of these skills.

Only a few interventions focused on abilities that were defined more broadly and, therefore, impacted on several sub-skills, such as attention (Bartoli, Corradi, Garzotto and Voloriani, 2013; Hiniker, Daniels and Williamson, 2013), or other daily life skills (De Urturi, Zorilla and Zapirain, 2011; Hassan et al., 2011; Yan, 2011). However, other studies that make use of different methods from those examined in this study, such as ABA, are working with sense perception and other broader defined abilities too (Baranek, 2002). Therefore, a consequence may emerge from this study, which also focuses on these skills in future interventions using game-methods. Matson et. al (2012) state that interventions using other methods also aim at the comorbidities associated with autism, such as anxiety disorders or depression. This implies that future interventions should also use game-methods to find out whether those methods could also achieve improvements in the comorbidities. Still, it is reasonable that further interventions should focus on communication skills, since this a major issue within autism. Finally, it can be expected that since the new DSM-5 (American Psychiatric Association, 2013) definition of autism, specifically mentioning hyper-and hypo-reactivity to sensory input, more interventions would be developed covering those issues. Nonetheless, no such interventions were found. More recently though, after the publication of this review, there was a paper on body awareness. This will be described further in this section, with regard to motion based touchless technologies. Although children with autism can have many difficulties, video games are one activity they can excel at. Griffiths (2003), suggests that videogames, used in the right context, can have the potential to be used as training tools in classrooms and therapy settings, to provide skills in motor coordination, and create simulations of real life events. One of the major problems with this area of research is that reported positive effects from video games related to the bespoke games used, rather than those that were commercially available.

3.7 Augmented reality

Augmented Reality (AR) can be considered a variation of Virtual Reality (VR) (Azuma, 1997). A VR environment offers a completely immersive experience to the user, with which can interact, while not seeing the outer real world. However, AR technology allows the user to see the real world with virtual objects superimposed, or merged, with real elements and surroundings (Trojan et al., 2013). Another important element of AR environments is that, virtual and real objects co-exist and interact in real time. Because of these characteristics, individuals with autism might be able to generalise their learning to new situations more easily, compared to a VR system (Casas, Herrera, Coma and Fernandez, 2012). This is because AR requires less abstraction capacity than VR, which is completely immersive. The applications of AR are broad and their numbers are increasing rapidly (Chessa et al., 2012). In the last few years AR has increasingly been used in education (Wojciechowski and Cellary, 2013), with not only young typically developing children (Kerawalla et al., 2006) but also with children with special needs (Richard, 2007; Chang et al, 2013).

Augmented Reality can lower the barrier to entry for students engaging in virtual content. The ease of interaction within AR-based experiences has already been shown by the use of virtual experiences in early school years (Bujak et al., 2013). People with developmental conditions may experience limitations in fine motor control, strength and range of motion, which can reduce their participation in community and leisure activities (Chang, Chen and Huang, 2011). Custom-made alternative devices for those with special needs are expensive and the low unit turnover makes the prospect unattractive to potential manufacturers (Standen, et al., 2011). However, recent years have seen the development of video games that are not only for fun, but also educational. Platforms such as Microsoft Xbox Kinect and Nintendo Wii can provide an AR environment and also allow for free body input for the manipulation of the environment. These technologies are referred to as motion based touchless technologies and are going to be presented in more detail in the next sections.

3.8 Motion-based touchless technologies

As mentioned in the previous chapter, the potential of motion-based touchless technologies is grounded on theoretical approaches that recognise the relationship between physical activity and cognitive processes, and, more specifically, build on the embodied cognition. The cognitive processes linked to mastering sensory-motor contingencies originate from embodied experiences; but some higher-level cognitive skills, such as mental imagery, working memory, implicit memory, reasoning and problem solving, also arise from sensory-motor functions. This hypothesis is also supported by the results of empirical studies that include typically developing children and by arguments based on pedagogical practices. Kynigos et al. (2010) in their study presented a set of collaborative full-body digital games designed to understand what meanings learners develop during body-movement and gestures. Authors reported that children perceived body motion as a natural way to interact and mutually communicate, and directly connected their body actions with the mathematical concepts embedded in the games. Additionally, Bartoli et al. (2013) conducted a study with five children with autism using a set of motion-based touchless video games, in order to investigate the relationship between body involvement and engagement in educational motion-based gaming. The study revealed that an increase in body movement resulted in an increase in the player's engagement level, attention and positive emotional response. The two big platforms that allow motion-based touchless gaming are the Xbox 360/Microsoft Kinect and the Nintendo Wii. These are explored below.

3.8.1 Xbox 360/ Microsoft Kinect

The Xbox 360/ Microsoft Kinect is a motion sensor originally used for video games. It provides a natural user interface that allows users to interact without an intermediary device (e.g. a controller). The Kinect system identifies individual players through face, body and voice recognition. Due to the way that it operates, it has the potential to enhance kinesthetic learning; a process through which students can be physically involved in learning. The Kinesthetic Learning Activity (KLA) was proposed by Begel et al. (2004) as a pedagogical tool which engages students by putting them in physical motion. As part of this type of activity, students might walk, jump, point or talk (Sivilotti and Pike, 2007). A number of studies discussed the potential of Kinect applications for teaching and learning at school. Kanndroudi and Bratitsis (2012) analysed seven popular Kinect games with respect to a set of theoretically grounded learning principles and provide a categorisation that can help educators to use this technology for teaching physical, cognitive, emotional and social skills. According to Hsu (2011), motion-based educational activities can facilitate kinesthetic pedagogical practices for learners with strong bodily-kinesthetic intelligence (who learn better when they are physically involved in what they are learning). Additionally, Hsu (2011) argued that the Kinect system has the potential to increase interactions and participation in the classroom and give teachers a tool that can improve their ability to present and manipulate multimedia and multimodal materials. Casas et al. (2012) and Herrera et al. (2012) described a Kinect-based game, called Pictogram Room, which aimed at promoting the development of self-awareness, body schema and posture and imitation skills. The system was designed as an augmented mirror where children could see themselves as virtual puppets, integrated with virtual characters that behave according to children's movements. An attempt of "pet therapy" is explored in Chia and Li (2012) to improve the communication and learning skills of autistic children. The paper describes a Kinect application, enabling touchless motion-based interaction with virtual dolphins, and proposes a detailed questionnaire to measure the effects on the gaming experience (without reporting any evaluation results).

The number of works that investigate motion-based touchless experiences for children with autism is limited. The MEDIATE project (Pares et al., 2005) provides a Kinect-based immersive, multimodal and multisensory environment aimed at fostering a sense of agency (the consciousness of being able to exert control over the surrounding environment and obtaining a coherent response) and a capacity for creative expression. Young people on the autism spectrum are overwhelmed by the excessive stimuli that characterise interaction in the physical world and tend to withdraw into their own world. Hence the stimuli offered by the MEDIATE system are focused and simplified, yet at the same time dynamic and engaging, capable of affording a wide range of creative behaviours. Evaluations in public settings, with more than 90 children with autism, showed that the MEDIATE environment stimulated curiosity and engagement (the playtime, for example, varied from five to 35 minutes). Pre-post tests administered to 12 children revealed no feeling of discomfort and showed gains in terms of sense of control and agency. Zalapa et al. (2013) and Ringland et al. (2014) described the design and development of Sensory Paint, a system that enables children with autism to control a multisensory environment using body movement and tangible interactions. Sensory Paint displays the shadow of the user to provide feedback, adjusts the instrumental music playing in the background according to the children's movements, and tracks their interactions with balls that change colours. Sensory Paint uses the Kinect sensor and computer vision in order to recognise interactions between users. Although, Ringland et al. (2014) stated that the game was developed to target body awareness, in their evaluation with 15 participants, they examined the accuracy of the software, how easy it was to implement and how fun and engaging was for the children. Some participants (n=5) engaged only with one aspect of SensoryPaint (*e.g.,* scribbling with the paint, throwing the ball to make splashes, or only using the paint to color in shapes). However, other children (n=10) engaged with multiple aspects of the system. These children would more often play with the system until they had tested its boundaries and discovered all potential functionality. They would then abandon the system, either asking the researcher which mode was next or simply stop engaging altogether. Feedback from the interviews gave the authors some insight into the participants' reaction to SensoryPaint. Of the 15 participants, 10 said they thought the game was fun and were enthusiastic about their experience but 5 of them found it boring. It is also important to note that these Kinect-based studies were not deployed in the children's natural environment but they were lab based.

3.8.2 The Nintendo Wii platform

The Nintendo Wii is one of the latest generation of video games consoles. It incorporates a number of innovative features designed to target a broader demographic of users, compared to other gaming systems. Its distinguishing feature is the wireless controller, the Wii Remote, which contains a sensor able to detect motion and rotation in three dimensions. The wireless controller is not based on the traditional gamepad controller design, but instead assumes a one-handed remote control-based design. This control method is intended to make motion sensitivity more intuitive, and the remote design is suited perfectly for pointing, making the device seem more familiar to the non-gaming public. It allows players to control elements of the game, such as swords or tennis rackets, by pointing at the image on the screen and moving their arm and hands. This level of physical interaction with the games is innovative in mainstream gaming, and this, combined with the nature of the games available for the Wii (such as Wii Sports), has specific considerations in terms of accessibility and engagement, as well as the social aspects of gaming.

Dickinson and Place (2014) used a set of commercial games on the Nintendo Wii ("Mario and Sonics at the Olympics") for improving fitness levels in children with autism. They conducted a randomised control trial with 100 children and young teenagers with autism (50 in the intervention and 50 in the control group). At the end of the year, participants of the intervention group had significant improvements in their cardiopulmonary function and fitness level, as measured by the Eurofit physical fitness battery (Council of Europe, 1993), compared to the control group. No studies were found focusing on improving sensory-motor skills in individuals with autism with the Wii platform. However, there were studies focusing on those skills for children with

Down Syndrome (Wuang et al., 2011; Rahman, 2010; Berg et al., 2012) and cerebral palsy (Jelsma et al., 2013). Berg et al. (2012) conducted a case study with a 12-year-old boy, diagnosed with Down Syndrome, using Wii games. The participant used the games at home, four times a week for 20 minutes sessions, lasting for a period of eight weeks. They found improved postural stability, upper-limb coordination and balance as measured by the Bruininks-Oseretsky Test of Motor Proficiency, 2nd edition (BOT-2; Bruininks and Bruininks, 2005). Rahman (2010) used the same test to target similar skills in 30 children (aged 10 to 13 years) with Down Syndrome, after they had used the Wii platform. The children were randomly assigned to an intervention or the control group and after the end of the study they found improved balance for the intervention group. Wuang et al. (2011), in their study, compared traditional occupational therapy with gaming using Wii in 105 children with Down Syndrome. Children were randomly assigned to intervention with either traditional occupational therapy or Wii, while another 50 served as controls. All children were assessed with measures of sensory-motor functions. At post-intervention, the intervention groups significantly improved, compared to the control group, on all measures. Participants in the Wii group, had a greater pre–post change on motor proficiency, visual-integrative abilities, and sensory integrative functioning. Finally, Jelsma et al. (2013) evaluated the impact of training using the Nintendo Wii Fit in 14 children with spastic hemiplegic cerebral palsy, using a single-subject design. At the end of the intervention improved balance, as measured by the BOT-2, was noticed for all participants. Similarly to the studies using the Microsoft/X-box Kinect, the Wii-based studies were implemented in labs and not in the children’s natural setting with the exception of the Dickinson and Place’s (2014) study that was conducted in three schools.

3.9 Summary

As found in the literature, sensory based interventions use a variety of sensory modalities (e.g. vestibular, proprioceptive, auditory) as target behaviours, that may or may not be associated with sensory-motor skills. They also involve a continuum of passive to active child participation, and are applied in different contexts, such as schools or clinics. These interventions arise from different conceptualisations about sensory integration (e.g. SI theory and theory of optimal arousal). This variation in sensory interventions combined with inconsistent use of terminology has resulted in considerable confusion for parents, practitioners and researchers. Despite inconsistency in the research literature, sensory interventions are among the services most requested by parents of children with autism (Green et al., 2006). To increase understanding of the different types of sensory interventions, and to assess the evidence, the researcher distinguished SI therapy (a clinic-based, child-centred intervention, that provides play-based activities with enhanced sensation to elicit and reinforce the child adaptive responses, (Ayres, 1972) from Sensory Integration-Based (SIB) approaches (structured, adult-directed including sensory strategies that are integrated into the child's daily routine to improve behavioural regulation (Case-Smith et al., 2014). Furthermore, there was a reference to physical exercise, as it has been used traditionally for development of sensory-motor skills. Results on the efficacy of those interventions were mixed, as in many cases there are methodological issues (e.g. van Rie and Heflin, 2009), limited participant information (e.g. Sowa and Meulenbroek, 2012) or many differences in the nature of the intervention (e.g. Lang et al., 2010). The researcher also made reference to the application of TEL for sensory-motor interventions in autism. Previous research on the use of technology and gaming has shown that these can offer many benefits to individuals with autism

(Noor et al., 2012). However, research specifically for sensory-motor skills using TEL is limited. Only recently, with the advancements in gaming platforms such as the Nintendo Wii and the Xbox/Microsoft Kinect, there are studies targeting some of these skills (e.g. Zalapa et al., 2013). Finally, most of the technologies used are specifically developed for the purposes of the study and are mainly implemented in labs and not children's natural environment (e.g. home. Classroom etc.), where researchers can potentially have input from parents, clinicians and teachers. This makes it hard to assess for the intervention effectiveness.

The next chapter focuses on the research design of the proposed doctoral study. More specifically, the research design, philosophical underpinnings and the methodological approach are stated. Additionally, the research questions and the aims of the study are presented. Finally, there is reference to the setting and the sample with which the study was conducted.

CHAPTER 4

METHODOLOGY: PHILOSOPHICAL UNDERPINNINGS, RESEARCH DESIGN AND METHODOLOGY OF THE STUDY

4.1 Introduction

The literature indicated that sensory-motor difficulties are present in many children with autism. Moreover, there are few existing specific interventions to address these issues. Recently, increasing attention has been given to technology-based interventions. There is, therefore, a need for more research to identify evidence-based practices in this domain. This study therefore aims to implement a technology-based intervention supporting the sensory-motor development of children with autism in a school setting. The methodology of the study is split into two chapters. This chapter presents the design of the study, as well as its philosophical underpinnings. The researcher then describes the methodology of her study, which involved a combination of quantitative and qualitative approaches, thus using a mixed methods design. She then presents the research questions of the study and how the mixed methods design will help her answer those. The researcher reports some criticisms of this design but nevertheless justifies why it was still a good fit for her study. The chapter concludes by presenting information on the participants and the setting in which the study was conducted.

4.2 Research Design

According to Mouton (1996, p. 175) the research design serves to 'plan, structure and execute' the research to maximise the 'validity of the findings'. Yin (2003a) adds further that a research design is 'the logical sequence that connects the empirical data to a study's initial research questions and, ultimately, to its conclusions'. (p. 19). One could say that the research design is a blueprint of research, dealing with at least four matters: what questions to study, which data is relevant, what data to collect, and how to analyse the results (Cohen et al., 2011). Its main purpose is to help avoid the situation in which the evidence does not address the initial research questions. It includes defining the research problem, constructing the research questions, collecting the data, analysing these and writing the final report. There are many different research designs, but a common classification of designs follows the typology of research paradigms. In that sense, there are quantitative or fixed and qualitative or flexible designs. The distinctive hallmark is that in quantitative designs there is a great deal of pre-specification before the fieldwork, whereas in flexible qualitative studies, the design evolves and develops during the research process (Robson, 2002). Among the most common quantitative designs are experiments, quasi-experiments, and surveys. The most widely used qualitative designs are case studies, ethnographies and grounded theory. There is a third design, which combines features of both quantitative and qualitative research designs; the mixed methods design (Cresswell and Clark, 2007; Denscombe, 2010). Usually the researcher decides to use a design depending on the research questions he or she wants to address, but also depending on his or her philosophical worldviews. The next section not only describes the philosophical underpinnings of the different study designs, but also reports on the philosophical views of the researcher for this study and how these shaped the choice of the research design for this study.

4.3 Philosophical underpinnings in research

This section discusses the most common philosophical theories influencing social and educational research. It defines terms such as ontology, epistemology and methodology and concludes by reporting the philosophical foundations of this study. The philosophical underpinnings of a study are often unrecognised or taken for granted in educational research (Scott and Usher, 1999). However, research is not just a technical exercise as it is highly related to the way the researcher views, understands and interprets the world (Cohen et al., 2011). This means that the researcher's values and beliefs play a critical role on how they conduct research. This set of values and beliefs is what is referred to as paradigm (Kuhn, 1962; Bailey, 2008; Babbie, 2013). There is not a universal consensus on the number and the content of research paradigms (Burrell and Morgan, 2005; Johnson et al., 2007). This study embraces the view that there are three main research paradigms in social science and educational research; the positivist, the interpretivist and the pragmatic (the mixed methods) paradigm (Johnson et al., 2007). A paradigm consists of the following components: ontology, epistemology, methodology and, methods. Each component is explained below, and the relationships between them are explored.

Questions of an ontological nature are concerned with what constitutes reality, in other words, ontology is the study of being (Burrell and Morgan, 2005). Guba and Lincoln (1994), suggest that *ontology* answers the question '*What is the nature of reality*?' Assumptions of an epistemological type are connected to the ways of seeking knowledge and researching the nature of reality and things (Cohen et al., 2011). According to Scott and Usher (1999), *epistemology* is concerned with '*how do we know what we think we know*?' To summarise the above, ontology represents the way the researchers interpret the reality, and epistemology the way they approach the knowledge. Different paradigms inherently contain differing ontological and epistemological views; therefore, they have differing assumptions of reality and knowledge, which underpin their particular research approach. This in turn is reflected in their methodology and research methods.

Positivists support the existence of an objective reality (ontology). The researcher should approach it by being neutral to the subject of research (epistemology) and try to explain relationships between variables mainly using quantitative data (methodology) (Creswell, 2003; Cohen et al. 2011). Interpretivists, on the other hand, believe that reality is relative which means that it is subjective and differs from person to person (ontology), different people might form meaning in different ways (epistemology) and therefore, qualitative data is primarily used to understand the individual's perspective (methodology) (Cohen et al., 2011). The researchers who are strong believers of one paradigm (e.g. positivism) and exclude the other (e.g. interpretivism) are often called purists (Onwuegbuzie and Leech, 2005). Recently, there is a tendency for researchers to question this strict paradigm discrimination and seek more alternative and flexible ways to approach research (Cohen et al., 2011). These researchers follow the pragmatic or mixed methods paradigm and support the idea that researchers should use methods that work best for each piece of research and can best explain what they want to study (Robson, 2002; Onwuegbuzie and Leech, 2005; Denscombe, 2010).

4.3.1 Methodology

This study operates within the pragmatic paradigm, as the methods that have been selected best suit the overall purpose of the study and answer the different research questions. The *Methodology, which* is the plan of action that exists behind the choice and use of particular methods (Cohen et al., 2011), is thus concerned with why, what, from where, when and how data is collected, analysed and interpreted. Guba and Lincon (1994, p. 108) explain that methodology asks the question: 'how can the inquirer go about finding out whatever they believe can be known?' Research *methods* are the specific techniques and procedures the researcher uses to collect and analyse data (Cohen et al., 2011). The methodology for this study uses both quantitative and qualitative data to answer the research questions with an emphasis on quantitative data. In other words, the researcher followed a mixed methods approach. Before moving on to how the researcher utilised this design to answer the research questions, it is essential to provide some background information on the purpose of using a mixed methods design and what its types are, so as to better understand the researcher's choices for this study.

4.4 Mixed methods design

A mixed methods study is one that includes a qualitative and quantitative dimension, but difficulties often arise when the researcher attempts to articulate how the two elements relate to one another (Tashakkori and Creswell, 2007). There is an inconsistency among researchers about what constitutes mixed methods research (Sandelowski, 2001; Bryman, 2007; Tashakkori and Creswell, 2007). Some interpretations view mixed methods as the collection and analysis of quantitative and qualitative data. More contemporary studies in this area have sought to develop an understanding of the importance of the integration of the two approaches (Hanson, et al., 2005; Bryman, 2007; Creswell and Clark, 2007). Tashakkori and Creswell (2007) argue that as mixed methods research is still evolving, the discussion of what actually is a mixed methods design should be kept open. Similarly, Johnson, et al. (2007) suggest that the definition of mixed methods research will change over time as this research approach continues to grow. Mixed methods research has been established as a third methodological movement over the past twenty years, complementing the existing traditions of quantitative and qualitative movements (Tashakkori and Teddlie, 2003, Teddlie and Tashakkori, 2009). This development has been accompanied by a search for an appropriate paradigm, to provide a strong justification for the use of mixed methods, comparable to the paradigms that have been widely accepted as justifying the use of quantitative and qualitative methods separately. The term 'mixed methods' has come to be used to refer to the use of two or more methods in a research project yielding both qualitative and quantitative data (e.g. Creswell and Clark, 2007; Teddlie and Tashakkori, 2009).

Many reasons have been identified for conducting a mixed methods research study. Following a review of theoretical and empirical literature, Greene, et al. (1989) identified five purposes for conducting mixed methods research designs. These are triangulation, complementarity, development, initiation and expansion. Bryman (2006), in a later review of 232 social science mixed methods papers, identified 16 reasons for conducting mixed methods studies. Many of the rationales identified in Bryman's (2006) analysis are similar to those identified by Greene, et al. (1989) although they are more detailed in manner. *Triangulation* allows for greater validity in a study by seeking corroboration between quantitative and qualitative data (Greene, et al. 1989; Bryman, 2006). *Complementarity* refers to the use of a combination of research approaches, so as to provide a more complete and comprehensive picture of the study phenomenon (Greene, et al. 1989). Many authors argue that using a mixed methods approach can allow for the limitations of each approach to be neutralised while strengths are built upon, thereby providing *stronger and more accurate inferences* (Creswell, et al., 2003; Bryman, 2006). Additionally, this design helps to a*nswer different research questions.* Creswell and Clark (2007) argue that mixed methods research helps answer the research questions that cannot be answered by quantitative or qualitative methods alone and provides a greater repertoire of tools to meet the aims and objectives of a study. Bryman (2006) suggests that this is a way to put 'meat on the bones' of dry quantitative data. Furthermore, it is used for *hypotheses development and testing,* as a qualitative phase of a study may be undertaken to develop hypotheses to be tested in a follow-up quantitative phase. Also, it can be used for *instrument development and testing* as a qualitative study may generate items for inclusion in a questionnaire to be used in a quantitative phase of a study (Greene, et al. 1989). Finally, a mixed methods approach can lead to better *explanation of findings.* This is because mixed methods studies can use one research approach (i.e., quantitative or qualitative) to explain the data generated from a study using the other research approaches. This is particularly useful when unanticipated or unusual findings emerge (Creswell and Clark, 2007). For example, findings from a quantitative survey can be followed up and explained by conducting interviews with a sample of those surveyed to gain an understanding of the findings obtained.

4.5 Types of designs in mixed methods

In an attempt to clearly identify the types of mixed methods research, many authors have developed typologies or classification systems of mixed methods designs (Creswell, et al., 2003; Teddlie and Tashakkorri, 2006; Creswell and Plano Clark, 2007; Leech and Onwuegbuzie, 2007; Tashakkori and Creswell, 2007). Tashakkori and Teddlie (2003 p.680) state that the determination of a typology is 'among the most complex and controversial issues in mixed methodology'. The main advantages of having a typology of mixed methods include the conveying rigor regarding the methodology, providing guidance and assisting in the development of language for mixed methods research (Bryman, 2006; Teddlie and Tashakkorri, 2006).

In this section, two recent classification systems developed by Creswell and Clark (2007) and Leech and Onwuegbuzie (2007) will be outlined. The first question when deciding on methodology is to ascertain which approach will best suit the research question. This is a fundamental issue that all researchers need to address, and Creswell and Clark (2007) have stressed the importance of justifying the selection of a mixed methods approach to conduct research. Creswell and Clarke (2007), as well as Leech and Onwuegbuzie (2007), suggest that there are three major decisions to make before selecting a particular type of mixed methods design. The first decision relates to whether to conduct the qualitative and quantitative stages concurrently or sequentially. Furthermore, deciding whether both the methods are given equal priority is another key decision. The third issue is to ascertain where the mixing of the qualitative and quantitative methods will occur. O' Cathain, et al. (2007), reporting on a review of mixed methods studies, identified that two-thirds were sequential, the majority gave priority to the quantitative methodology and integration occurred largely at the interpretation stage (81%, n = 39) in comparison to the analysis phase (17%, n = 8).

Creswell and Clark (2007) have developed a typology of mixed methods designs, which identifies three main types. The triangulation design is the most common and well-known design (Creswell, et al., 2003). The quantitative and qualitative phases occur at the same time, and both the methods are usually given equal weighting. The traditional model of triangulation mixed methods design is the convergence model, where integration occurs during the interpretation phase. The second type is the embedded design, and is characterised by having one dominant method, whereas the other method provides a secondary or supportive role. The embedded experimental model is the most common variant of the embedded design, and the priority is given to the quantitative methodology, with the qualitative data set being subservient (Creswell and Clark, 2007). One of the purposes of the qualitative component may be to examine the process of the intervention. Within the embedded designs, the methods may be conducted concurrently or sequentially. Finally, the explanatory design, previously described by Creswell et al., (2003) as sequential explanatory design, consists of two phases; beginning with the quantitative phase and then the qualitative phase, which aims to explain or enhance the quantitative results. The two variants of the explanatory design; the follow-up explanatory model and the participant selection model. Within the follow-up explanatory model, the researcher identifies specific quantitative findings, such as unexpected results, that need further exploration using qualitative methodology. In contrast, the qualitative phase has priority in the participant selection model, and the purpose of the quantitative phase is to identify and purposefully select participants. The explanatory design requires a longer implementation time due to the sequential nature but is regarded as the easiest of the four methods to implement. The exploratory design is a sequential design where the first qualitative phase helps in the development of the quantitative phase. This design is commonly used for developing and testing instruments and interventions or for developing a taxonomy.

Leech and Onwuegbuzie (2007) use three criteria to develop their three dimensional typology of mixed methods design, and these include the level of mixing, time orientation and emphasis of approaches. Partially mixed studies are described as those studies where both the qualitative and quantitative phases are conducted independently, before mixing occurs at the data interpretation stage. In contrast, fully mixed methods designs have mixing occurring in either one or all of the following: the research objective(s), the types of data, analysis and inference. The first layer differentiates the studies into either partially or fully mixed designs, the second decides on the timing of the different phases of data collection, and finally whether each methodology is given equal status within the chosen design. This classification system results in six mixed methods designs, which are: partially mixed concurrent equal status design, partially mixed concurrent dominant status design, partially mixed sequential equal status design, partially mixed sequential dominant status design, fully mixed concurrent dominant status design and fully mixed concurrent dominant status design. The major limitation to this classification system is the division of mixed methods into partially mixed and fully mixed studies. As identified, choosing the most appropriate design for a mixed methods study depends on a number of factors. This includes deciding which approach is best suited to answering a particular research question and the overall rationale for using a mixed methods approach.

Before outlining the research questions, the researcher explores some criticisms of the mixed methods design.

4.6 The criticisms of mixed methods research

Although it is clear that a mixed methods approach has much to offer the researcher, there have been criticisms of its use. Many of these criticisms focus on the incompatibility thesis that is the belief that quantitative and qualitative research methods cannot be mixed in a single study as they have such different ontological and epistemological origins. Methodological purists believe strongly in the dichotomy of worldviews and research methods (Creswell and Clark, 2007) and, therefore, argue against the combination of quantitative and qualitative approaches. However, Onwuegbuzie (2002) suggests that positivist and non-positivist philosophies lie on an epistemological continuum, with mixed methods research occupying the middle ground. Similarly, Howe (1988) argues against the incompatibility thesis and instead suggests that researchers should adopt a pragmatic approach and forge ahead with 'what works'. Mertens (2003) who herself is an avid believer of mixed methods, poses some questions about the pragmatist philosophy. She argues that basing methodological choices solely on pragmatics or 'what works' is inadequate as it does not answer the question 'practical for whom and to what end?' However, many authors would suggest that the practicality inherent in pragmatism is concerned with finding the most appropriate method to answer a research question or set of research questions. Tashakkori and Teddie (2003) argue that researchers within the pragmatist tradition consider the research question to be more important than either the method or the paradigm that underlies it.

Other criticisms or weaknesses of a mixed methods approach are more practical in nature. Johnson and Onwuegbuzie (2004) suggest that it may be difficult for one researcher to carry out a mixed methods study if the qualitative and quantitative phases are to be undertaken concurrently. In this case, a research team may be required. Ivankova, et al. (2006) stresses that sequential studies also have drawbacks as it may take considerable time and resources to undertake distinct phases of a study. Within a mixed methods study, there is also a requirement that the researcher has at least a sufficient knowledge of both quantitative and qualitative methods independently and how to mix these methods appropriately to achieve good study outcomes. Despite the drawbacks to using a mixed methods research approach, the researcher appreciates these criticisms and tries to combine the different methods in a way that it will make her study more holistic and to focus on better answering her research questions (Tashakkori and Teddie, 2003). Therefore, the next section presents the methodology of the study and the approaches the researcher followed for obtaining the quantitative and qualitative data. As pointed out by Creswell and Clark (2007) and Leech and Onwuegbuzie (2007), the research question is the starting point and the main element that is going to lead to the specific choice of type in a mixed methods study. Therefore, in the next section, the researcher presents the aims and the research questions of the study, then gives a justification of the methodology that was followed and how she went about answering the research questions.

4.7 Aims of the study and research questions

The overarching research aim was to use a game-like free movement technology environment as an intervention, to measure its effects on the sensory-motor skills development of a group of children with autism and the generalisation of these skills outside the software environment.

The main research questions of the study were:

1. Can Pictogram Room enhance the sensory-motor skills of children with autism?

2. In which environment/s do the sensory-motor skills of the children with autism develop to a greater extent (i.e. Software, Classroom, Home, Physical Education, Playground)? Were they generalised outside the Software environment?

3. Which sensory-motor sub-domain improved more (i.e. Balance and Motion, Body Awareness and Planning and Ideas)?

4. Are the findings of the first three research questions different when just analysing the data from an intervention group compared to when comparing the intervention to a control group?

5. What are the ways that Pictogram Room can be used in a school setting?

Post-hoc research question from the teachers' interviews:

6. Were there any differences in social play and adaptive skills between the intervention and the control group?

4.8 Research design of the study

Following the pragmatic approach, the researcher chose a mixed methods design for a number of reasons. Firstly, she wanted to use mixed methods for data triangulation to provide better validity of the results. Furthermore, a mixed methods approach would help her answer different research questions, which in turn would lead to a greater completeness and a follow-up analysis of data. Finally, by using a qualitative approach in addition to the quantitative data, it would help the researcher to form a better picture of the effectiveness of the intervention and inform future research practice (Creswell and Clark, 2007). The mixed methods type she followed was the explanatory sequential design according to the typology of Creswell and Clark (2007), with the quantitative data being more dominant and the qualitative data being there in a more supportive way. Using the Leech and Onwuegbuzie (2007) typology, this study is using a partially mixed sequential dominant status design. As will be described later, the researcher gathered qualitative and quantitative data. The qualitative data was gathered after the quantitative data, with the aim that it would further inform the quantitative results but would serve as the way to investigate information that could not be captured by the quantitative data alone. It would also help to design the next steps of the study. The researcher decided to use the typology of Leech and Onwuegbuzie (2007) because she felt that the name captured more precisely the process she followed. More specifically, it shows that the main data collected was quantitative and only partially mixed with the qualitative data. Although the latter provided important insights, it was not as powerful as the quantitative data.

Quantitative data was primarily used (as the dominant method) to answer the first four research questions. More specifically, the quantitative data was used to compare differences in the children's sensory-motor skills pre and post-intervention to see its effectiveness, to test for generalisation of skills in different environments and finally to see which of the three sensory-motor subdomains might have been improved more. The qualitative data gathered served different purposes. Firstly, it was used in addition to the quantitative data, regarding the first research questions for the intervention group, as the sample of the study was small and potential differences in the quantitative data might have over or under-estimated the effectiveness of the intervention. Besides that, as it will be seen in the following sections that describe the methodology in detail, the interview data served as a tool to examine whether teachers thought any potential changes observed in children could be due to other factors (e.g. maturation, other interventions taking place at the same time). Additionally, the interviews helped the researcher consider whether, the teachers' overall views about the intervention could inform the researcher about whether the intervention could have been implemented differently.

4.9 The research methodology of the study

The study utilised a single-subject approach to see the effectiveness of the intervention in the intervention group, and a group design approach to see potential differences between the intervention and the control group. These two approaches were used to gather the quantitative data and then interviews were used to gather the qualitative data. These designs are very different, and although experimental designs might be more rigorous (Horner, Carr and Halle et al., 2005), the researcher felt that just their use might not have been enough to capture the ecological realities of the classroom (Johnson, 1997). The approaches the researcher followed are described in the following sections.

4.9.1 Single-Subject Approach

Single-subject experimental design is originated in the work of B. F. Skinner (1953). Experimental research is regarded as the 'scientific' approach to research (Verma and Mallick, 1999). Although psychologists are known to mainly use experimental methods, Thorndike (1924) was one of the early investigators who extended the experimental method into education. Single-subject research methodology has a long tradition in education as well as behavioural sciences (Gast and Ledford, 2009). Baer, Wolf and Risley (1968) used this approach to evaluate intervention effectiveness with individuals. Single-subject design has been used in a number of disciplines, including psychology (Bailey and Burch, 2002; Skinner, 2004) and special education (Gast, 2005; Kennedy, 2005). The role of single-subject designs in systematic policies and procedures for promoting evidence-based practices in education has been emphasised (Horner et al., 2005).

Although we are referring to this approach as a single-subject research methodology, it is important to differentiate it from a case study, in which there is one case (e.g. individual, setting etc.) whose behaviour is described in detail. Single-subject research is a quantitative experimental approach, in which participants serve as their own control. This is known as "baseline logic" (Sidman, 1960). In that sense, participants are exposed to both "control" condition and an intervention condition. Depending on the research design used, baseline (A) and intervention (B) conditions may create different forms. There are several types of single-subject designs, such as basic designs (A-B), reversal or withdrawal designs (A-B; A-B-A; A-B-A-B; B-A-B), multi-treatment designs (e.g., A-B-A-C-A-C or A-B-A-C-B-C-B), multiple baseline designs and multiple probe designs.

The single-subject approach that was followed in this research was a basic A-B design. In an A-B design, A refers to the baseline phase and B to the intervention phase. This type of experiment only allows for correlational conclusions to be obtained. In this design, the dependent variable's performance is recorded in the baseline phase (A) and the intervention phase (B), and the performances during these two phases are then compared (Engel and Schutt, 2008; Hammond and Gast, 2010). The researcher used an A-B design to identify any possible improvement of the children's sensory-motor skills after the implementation of the intervention. This type of design is strong as it is easy and quick to apply in real world settings without having too many conditions that, in a busy classroom environment, would be very hard to control (Graham, Karmarkar and Ottenbacher, 2012).

Although the researcher chose the A-B design for the study, she is aware that there are some limitations. A-B designs have limitations in testing for gains or progress specific to the intervention or in addition to natural maturation. This happens because there are no control or comparison groups that would enable her to judge if there is actually an improvement (Robson, 2002). Furthermore, the small sample size is a significant drawback as it makes it hard to draw conclusions about the general population. The fact that individuals might be following different intervention programmes can also account for some changes in their behaviour (Jones and Jordan, 2008). Although to the knowledge of the teacher, none of the children were following an extra school programme. However, at the beginning of the study, in the middle of the baseline, one of the children had some sessions with an occupational therapist within the school, and this might have affected his performance. Maturation may also explain changes in the children's change of behaviour (Alnahdi, 2015) and its effects cannot be excluded from this study.

4.9.2 Group Approach

Group research methodology has been widely used in behavioural studies but there is an increase in its use in education (Gersten, Baker and Lloyd, 2000). It is used to evaluate intervention effectiveness in various disciplines, but mostly in psychology to evaluate clinical trials (Cohen et al., 2011). However, there is an increase in using group designs in special education as well (Gersten et al., 2005). In experimental group comparison designs, participants are divided into two or more groups to test the effects of a specific intervention. In the group comparison studies the researchers can study intervention and comparison groups through random (in randomized controlled trials) or non-random (e.g., group quasi-experimental designs, including regression discontinuity designs) assignment.

The researcher used a group quasi-experimental design for this study. Quasi-experimental studies take on many forms, but may best be defined as lacking key components of a true experiment. While a true experiment includes (1) *pre-post test design*, (2) an *intervention group* and a *control group*, and (3) *random assignment* of study participants, quasi-experimental studies lack one or more of these design elements (Cohen et al., 2011). Although the pre- post-test design will allow researchers to measure the potential effects of an intervention by examining the difference in the pre-test and post-test results, it does not allow to test whether this difference would have occurred in the absence of an intervention. For example, improved skills might have been due to the students' natural maturation. One way to get the true effects of the program or intervention, is to have both an intervention group and a control group. As the names suggest, the intervention group receives the intervention programme. The control group, however, receives intervention-as-usual conditions, meaning they only receive interventions that they would have received if they had not participated in the study (Robson, 2002). By having both a group that received the intervention and another group that did not, the researcher could control for the possibility that other factors not related to the intervention (e.g. simple maturation over the intervening time or other interventions) are responsible for the difference between the pre-test and post-test results.

As the quasi-experimental group design includes a pre- post- test design with both an intervention group and a control group, it is important to think how the assignment will be in each group. The two methods used for this are random or non-random assignment. Although the researcher was aware that random assignment (e.g. a randomised controlled trial) was more rigorous, the reality is that in quasi-experimental designs that take place in schools, as this research, that can be very hard to do (Hedges and Hedberg, 2007). Real-world research requires more flexibility and sometimes alternative methods of study design and collection of data (Gersten et al., 2000). The researcher decided to have a control group at a later stage, so she had to find participants from other classrooms, separate from the ones that she was working with. Numerous studies have recruited a control group separately from the intervention group. For example, Golan and Baron-Cohen (2006) and Turner-Brown et al. (2008) had to recruit the second group after they had started their interventions, because it was not easy to find participants that either matched the characteristics of the group or met the study inclusion criteria. Also, Ingersoll (2012) used the data of

22 children that had participated in one of her previous studies and recruited only 5 new participants that completed the intervention. This technique is very common in clinical trial studies (Pocock, 2013) for multiple reasons, including number or participants available, novelty of research and feasibility of the study.

Although the researcher is aware that this technique might pose threats to validity and reliability of the study, it was not feasible to recruit a control group at the same time as the intervention group. Unlike the previously mentioned studies that only matched the participants in various levels, the researcher, on top of that, recruited them from the same school and started working with them the same school period as the intervention group. By doing that, she ensured to a certain extent that both groups were following the same type of curriculum as they were attending the same school and they were at a similar stage in terms of what they had been taught. Finally, it is important to note that the control group would be a wait-list control group. Meaning that after a period of observation, which would allow the comparison with the intervention group, the children would receive the intervention with the software so as not to be excluded from the potential benefits the intervention would offer them (Gersten et al., 2000; Cohen et al., 2011). However, the data of the control group were not included in the thesis as two of the children moved to another school before the end of the study and due to some changes in the school’s schedule, the rest of the children did not manage to complete the whole set of sessions before the school closed for summer holidays.

4.9.3 Single-subject vs. group approach

Single-subject designs provide certain strengths and limitations relative to group research designs. Although concerns exist regarding the internal validity and external validity, many proponents of these designs nevertheless regard single-subject approaches as rigorous and scientific (Horner et al., 2005) and that they provide important methods of establishing evidence-based practices. The researcher’s ability to control (compare) the experimental participants with themselves is one of the characteristics of single-subject designs that has caused them to be the predominant approaches described in the experimental special education literature (Horner et al., 2005). This characteristic allows the researcher to overcome the heterogeneous nature of the special education student population, which can pose great difficulties in the construction of matching groups for the purposes of comparisons. However, this focus on individuals can also be perceived as a weakness of single-subject designs (Engel and Schutt, 2008) because it raises the issue of external validity; the generalisability of results in other contexts, settings and individuals that is not the case in group designs. External validity of the results from single-subject designs could therefore be enhanced, by replicating experiments across different conditions, participants and different measurements of the dependent variable (Horner et al., 2005). Another advantage of using single-subject designs is the flexibility of these designs to adapt to varying situations and educational settings. This flexibility allows progress to be monitored in applied settings rather than in experimental group contexts.

Another reason that single-subject designs are widely used in special education is that several types of these designs can generate causal inferences (Kratochwill, Hitchcock and Horner et al., 2010). Causal and functional inferences regarding changes in student outcomes are significant aspects of building evidence-based practices in special education (Tankersley et al., 2008). In addition, the fact that single-subject designs possess high internal validity, but can be accomplished in a cost-effective manner, causes these designs to represent an attractive alternative to traditional experimental designs, which require much larger sample sizes (Simonsen and Little, 2011). Moreover, single-subject designs are flexible and can be adapted to various situations and educational settings, allowing the progress of experimental subjects to be monitored in actual educational contexts. Single-subject designs are 'a rigorous, scientific methodology used to define basic principles of behavior and establish evidence-based practices. A long and productive history exists in which single-subject research has provided useful information for the field of special education' (Horner et al., 2005, p. 165). In single-subject research designs, 'as opposed to quasi- or pre-experimental designs, inferences can be drawn about functional relationships between independent variables and measured behaviors' (Wolery et al., 2011, p. 103). Although, as mentioned previously, quasi-experimental designs might lead to greater generalisation of the results, when the participants are not randomly assigned to groups, or sample size is not big, then we cannot make safe assumptions (Gersten et al., 2005).

However, the researcher, used a mixed methods approach to overcome these issues. Each of the methodologies used contributed to a better understanding of the results by combining different methods. To ensure that this design would be rigorous enough, the researcher followed a number of quality indicators. For the single-subject design approach, the researcher followed Horner's et al. (2005), prerequisites which are: (a) the practice to be operationally defined; (b) the context in which the practice is to be used is defined; (c) the practice to be implemented with fidelity; (d) results from single-subject research document the practice to be functionally related to change in dependent measures; and (e) the experimental effects are replicated across a sufficient number of studies, researchers, and participants to allow confidence in the findings and/or use multiple sources of data collection. Although, the researcher or any other researchers did not replicate the same study in other contexts, or with other participants, she has provided the information necessary if another researcher was to replicate the study. For the group approach, the researcher made sure that the dependent and independent variables were clearly defined and she gave a thorough description of the participants. She also included fidelity of implementation for the intervention and a variety of measurements for the results (Gersten et al., 2005). This brings the researcher onto describing the sampling.

4.10 Sample: Setting and Participants

There are two broad categories for sampling methods: ‘probability sampling’ ‘non-probability sampling’. ‘Probability sampling’ utilises some form of random selection and every person in the population has an equal chance of inclusion in the sample. On the other hand, in ‘non-probability sampling’, which is also known as judgment sampling, the researcher deliberately selects items for the sample, therefore sampling depends on subjective judgment. This particular study uses a ‘non-probability’ purposive sample, as most studies with a small number of participants tend to do (Burns, 2000; Denscombe, 2010). As Denscombe (2010) reports:

> *‘Purposive sample can […] be used as a way of getting the best information by selecting items or people most likely to have the experience or expertise to provide quality information and valuable insights on the research topic’. (p. 35)*

It is crucial to make a distinction between convenience and purposive sampling as different types of ‘non probability sampling’. A convenience sample is the one that the researcher has easy access to (Cohen et al., 2011), whereas a purposive sample is the one chosen to meet the researcher’s specific needs (Cohen et al., 2011). The limitation that both have is generalisation of the findings as they do not represent the wider population (Bryman, 2008). A purposive sample is also considered exploratory (Denscombe, 2010). In this study the sample is purposive, as the specific school and the participants were chosen because they meet several criteria and was exploratory. The school caters children with autism who have movement and sensory difficulties and they also expressed great interest in participating in the study. The following sections provide information on the setting and the participants.

4.10.1 Setting

The study took place in a mainstream school that incorporates three specialist resource base units for children with autism. Each unit has an average of seven students, all of them with a formal autism diagnosis. The age range for the units is five years old to nine years old. Some of the students follow the National Curriculum, while others follow an Extended National Curriculum that is tailored to the children’s specific needs. In each class there is one teacher and two teaching assistants. The school uses different approaches and interventions to meet their students' needs. These include Intensive Interaction (Nind and Hewett, 1994, 2001; Caldwell, 2008), TEACCH (Lord and Schopler, 1994) and Team Teach (Allen and Matthews, 2008). Over time the school staff have also developed their own programmes for assessing and teaching fine motor skills, communication, early literacy and numeracy and toilet training. The researcher first worked with this school as a Master's student and subsequently the staff had expressed interest in participating in various research studies. When she started her PhD, the researcher visited the school and discussed the project she had in mind and jointly decided on the focus and which children would be best to include.

4.10.2 Children Participants: Intervention and control group

During the collection of data for the intervention group, the school had two autism units with 14 students aged between four years old and nine years old. Teachers reported that 11 of them had sensory-motor difficulties. A consent letter was sent, from the school, to the parents of these children and to the children (see Appendix 1). All parents agreed for their children to participate in the study. Six children had to withdraw from the study as two of them moved to another school and the other four did not meet all the inclusion criteria. Therefore, five children comprised the final sample (See Table 1 for details about the children). The following year a new autism unit was opened at the school, with 10 more children aged between four years old and seven years old. This was the classroom that the researcher worked with to form the control group. The teachers reported that nine of the children have sensory-motor issues. The same consent letter as the one used for the intervention group was sent to their parents and all parents agreed for their children to take part in the study. Three children did not meet the criteria and one child had missing data so the final sample of the wait-list control group was comprised of five children as well (See Table 1 for details about the children). The specific inclusion and exclusion criteria for this study are described below.

The choice of the children was made according to the following inclusion criteria:

1. to have a diagnosis of autism and learning difficulties, but not to have any other diagnosis or condition which might have affected the study (e.g. attention deficit hyperactivity disorder, cerebral palsy, etc).

2. to be reported by their teachers as having sensory-motor difficulties

3. to confirm for sensory (related to movement) and motor difficulties through the Short Sensory Profile (Dunn, 1999)

4. not to have visual perception difficulties according to the Beery-Buktenica Developmental Test of Visual-Motor Integration, Sixth Edition (Beery and Beery, 2004)

Data on the children

In order to check whether the inclusion criteria were met, the researcher reviewed several reports about the children (e.g. statements of Special Educational Needs-SEN and other school documents). Also a number of checklists, tests and assessment tools were administered by school staff, parents and the researcher, these were:

- The Social Communication Questionnaire (SCQ: Rutter, Bailey and Lord, 2003)
- The Raven - Coloured Progressive Matrices (CPM: Raven, 1998, updated 2003)
- The British Picture Vocabulary Scale (BPVS: Dunn, Dunn, Whetton and Burley, 1997)
- The Short Sensory Profile (SSP: Dunn, 1999)
- The Movement Assessment Battery for Children-2 (MABC-2: Henderson et al., 2007)
- The Beery-Buktenica Developmental Test of Visual-Motor Integration, Sixth Edition (The Beery VMI: Beery and Beery, 2004)

Social Communication Questionnaire

The diagnosis of autism was obtained from the children's statements of special educational needs and was verified by administering the Social Communication Questionnaire (SCQ: Rutter, Bailey and Lord, 2003). SCQ is a 40-item questionnaire to be completed by the child's principal caregiver who is more familiar with the child's developmental history and behaviour. It is available in two forms - Lifetime and Current - each composed of just 40 'yes' or 'no' questions. In this study the researcher used the Lifetime form, because it focuses on the child's entire developmental history and identifies individuals who may have autism and should be referred for further evaluation. On the other hand, the Current form is only concerned with behaviour over the last three months. Because the SCQ is brief, quick, easily administered, and relatively inexpensive, it allows clinicians and educators to routinely screen children for autism spectrum disorders. This in turn permits early intervention. One thing that it is worthwhile to note is that although the SCQ is suitable for screening and monitoring, it is not suitable for diagnosis because it does not give information relating to onset, course and pervasiveness of symptoms across contexts. Moreover, it is based on caregiver reports, but for diagnostic purposes direct clinical observation is necessary. Total SCQ scores can range from zero to 39 and a total of 15 or more is the optimal score for autism and the researcher used it to confirm the autism diagnosis.

Berument et al. (1999) tested the SCQ validity on a sample of 160 individuals with Pervasive Developmental Disorders (PDD) and forty with non-PDD diagnoses. The non-PDD group included children with conduct disorder, language delay, mental retardation, and other clinical diagnoses. They found that the SCQ had good discriminative validity when differentiating PDD from non-PDD diagnoses at all IQ levels. The separation of autism from other types of PDD was not as strong. In its validation study (Berument et al., 1999), the SCQ was found to be highly correlated to the Autism Diagnostic Interview (ADI). The overall correlation between the SCQ total score and the ADI algorithm score was 0.712. The instrument was found to be as discriminative as the ADI in effectively screening for PDD.

Corsello et al. (2007) evaluated the SCQ alone and in combination with the Autism Diagnostic Observation Schedule in a clinical and research-referred sample of 590 children and adolescents (2 to 16 years), with best estimate consensus diagnoses of autism, pervasive developmental disorder, not otherwise specified (PDD-NOS) and non-ASD disorders. The SCQ was completed before the evaluation in most cases. Performance of the SCQ was also compared with the Autism Diagnostic Interview – Revised. Results: Absolute scores and sensitivity in the younger children and specificity for all groups were lower than reported in the original study. Using receiver operating curves to examine the area under the curve, the SCQ was more similar to the ADI-R total score in differentiating ASD from other disorders in the older (8–10, >11) than younger age groups (<5, 5–7). Lowering the cutoff score in the 2 younger groups improved sensitivity, with specificity remaining relatively low in all groups. Using the SCQ in combination with the ADOS resulted in improved specificity. Diagnostic discrimination was best using the ADI-R and ADOS in combination. For this reason, the authors suggested a change in the cutoff score for the SCQ depending on the children's ages to determine if they have autism. Therefore, in this study the researcher would consider children with a cutoff score of more than 19, although in the end the scores were over 20 suggesting more severe symptoms.

Raven-Coloured Progressive Matrices

The children's level of cognitive abilities was obtained by the Raven - Coloured Progressive Matrices (CPM: Raven, 1998, updated 2003). CPM consists of 36 jigsaws in three sets of 12: A, Ab, and B. It is designed to be used with both young children and old people for anthropological and clinical work. It can be used satisfactory with people that for any reason do not, or cannot, understand the English language. The three sets of 12 problems constituting the CPM are arranged to assess the chief cognitive processes of which children under 11 years of age are usually capable. The three sets together provide three opportunities for a person to familiarise and be consistent with the test requirements, and the test of 36 problems as a whole is designed to assess, as accurately as possible, mental development up to intellectual maturity. The non-verbal aspect of the assessment was very suitable for the study, as the participating children were non-verbal or minimally verbal and the researcher would not be able to obtain information on the children's cognitive level otherwise. Results in CPM include five Grades, which are: Grade I – Intellectually superior, Grade II – Definitely above average in intellectual capacity (II+ if the score lies at or above the 90th percentile), Grade III – Intellectually average (III+ if a score is greater than the median or 50th percentile or III- if score is less than the median), Grade IV – Definitely below average in intellectual capacity (IV- if a score lies at or below 10th percentile) and Grade V – Intellectually impaired.

Outcomes of a normative and reliability study on the CPM are reported for a sample of 618 children from Victoria Australia ranging in age from 6.00 to 11.92 years (Cotton et al., 2015). Internal consistency estimates ranged from a low .76 (11 year olds) to a high of .88 (for 8 and 9 years). Similar results were obtained for split-half reliability with values ranging from .81 (for 10 and 11 year olds) to .90 (9 year olds). Convergent validity evidence is provided when scores on an assessment relate to scores on other assessments that claim to measure similar traits or constructs. Years of previous studies on the CPM support its convergent validity (Raven, 1998).

British Picture Vocabulary Scale – Third Edition

The British Picture Vocabulary Scale - 3 (BPVS3: Dunn, Dunn, Whetton and Burley, 1997), which is a standardised test to determine the receptive language ability of the children. It is frequently used with both typically developing children and with those who have various conditions, both in clinical practice and in schools. The test consists of 14 sets of pictures and each set contains 12 vocabulary entries. As well as providing a standardised score for receptive language, the raw score can provide a verbal mental age for the child. This means that a child might have a calendar mental age of nine and a verbal mental age of seven; thus the raw score indicates a developmental delay or a deficit in receptive vocabulary. The reasons for including this measure is that it provided the researcher with some standardised and widely reported measure of a child's receptive language ability, as she needed to make sure that even if children were minimally verbal they could follow verbal instructions. Limited information exists regarding reliability and validity in the manual of the third edition of the BPVS. There are more references regarding the reliability of the assessment. Good reliability is reported with median Cronbach's alpha of 0.93 and median split-half of 0.86). Validity of this version is assumed as it is derived from the previous versions, but has not yet been independently established.

The Short Sensory Profile

The Short Sensory Profile (SSP: Dunn, 1999) is a 38-item caregiver report measure comprising the items that demonstrated the highest discriminative power of atypical sensory processing among all the items from the long version of the Sensory Profile (Dunn, 1999). Items are scored on a one-point to five-point scale. The seven sections of the SSP found in a normative sample are Tactile Sensitivity, Taste/Smell Sensitivity, Movement Sensitivity, Underresponsive/Seeks Sensation, Auditory Filtering, Low Energy/Weak, and Visual/Auditory Sensitivity. Given its short administration time (10 minutes) and value in screening for atypical sensory processing, the SSP is recommended for research protocols (Dunn, 1999; McIntosh et al., 1999). The scores on the total scale range from 38 to 190, with a more normal performance achieving a higher score. For the purposes of the study the researcher gathered data only on movement sensitivity. This was because only this specific part of the sensory profile was relevant to the study focus. The other parts of the assessment concern oral, visual, auditory and tactile information. Typical performance on movement sensitivity ranges from 13 to 15, probable difference from 11 to 12 and definite difference between three and 10.

The normative sample for the SP standardisation consisted of 1037 children from the US, 91% were white with a small percentage from other ethnic groups. Ages were 3 to 10 years, girls = 51%, boys = 49%, with data collected from 1993 to 1999. There were 110 to 140 children in each age band. Children were excluded from the normative sample if receiving special education services or were on regular prescription medication. For Internal consistency Cronbach's alpha calculations were performed and the results ranged from .47 to .91 with most items having adequate to good internal consistency. Content validity was established as part of test development using literature review, expert review and factor analysis (Dunn, 1999). For discriminant validity SP scores of children with autism (n=32) and Attention Deficit Hyperactivity Disorder (n=61) were sufficiently different from the normative sample to provide evidence of discriminant validity. That is, children in the clinical samples engaged in the behaviours listed on the Sensory Profile more frequently than the normative sample. For the children with autism, items that were most different were scattered across all factors on the Sensory Profile, evidence for the pervasive nature of autism. Sankar and Priyadarshini (2004) conducted a study as an effort to standardise the Tamil Version of Short Sensory Profile (SSP). Two hundred and fifty (n=250) Typically Developing Children and hundred (n=100) Sensory Processing Disorder children, aged 3 to 8 years were included through convenience sampling. SSP was administered individually to assess sensory processing abilities in children. The internal reliability of Tamil version of SSP was adequate and it discriminated typically developing children from SPD at .0001 level. The authors concluded that the SSP is a valid and reliable measure for sensory processing problems screening.

Movement Assessment Battery for Children-2

The Movement Assessment Battery for Children-2 (MABC-2: Henderson et al., 2007). MABC-2 is a standardised assessment to measure motor competence in children between three years old and 16 years old. It consists of two assessment components; The MABC-2 Test (quantitative and qualitative element) and a Checklist. For the purposes of this study the quantitative part of MABC-2 Test was used. The MABC-2 Test involves the child directly and he/she is required to perform a series of motor tasks in a strictly specified way. The test is divided into three age bands (ABs): AB1 – three to six years, AB2 – seven to 10 years and AB3 – 11 to 16 years. For this study the researcher used the first two bands as the children were between four to seven years old. Within each band, eight tasks (items) are grouped under three headings: Manual Dexterity, Aiming and Catching, and Balance. The administration of the tasks take 20 to 40 minutes. The test provides objective, quantitative data on movement competence. For every item, standard scores are provided and for the total score, age-adjusted standard scores and percentiles are provided. In addition, the total score can be interpreted in terms of a 'Traffic Light' system, which designates three zones. A score falling in the green zone indicates performance in the normal range. The amber zone designates a 'at risk' category, indicating that the child needs careful monitoring. The red zone indicates definite motor impairment. For this study, the test was administered and scored by an independent researcher who was qualified to do so. This assessment was used to confirm motor problems in the participants.

Limited information on reliability and validity are detailed in the manual. However, some preliminary reliability data for the MABC-2 Performance Test, based on the results of several studies completed by other investigators that involved experimental versions of the 3:0–6:11-year and 11:0–16:11-year age bands, are detailed. Visser and Jongmans (2004) report test-retest results for Age Band 1 assessment tasks for a group of 55 3-year-old children from the Netherlands. Pearson Product Moment correlation results ranged from 0.49 to 0.70. Chow, Chan, Chan, and Lau (2002) evaluated inter-rater and test-retest reliability of an experimental version of the 11:0–16:11-year Age Band 3 assessment tasks (with instructions and scoring criteria translated into Chinese) with a sample of 31 adolescents. Intra-class correlation (ICC) coefficients for inter-rater reliability varied from 0.92 to 1.00 while test-retest coefficients varied from 0.62 to 0.92. Content validity of the MABC-2 was established by input of an expert panel. According the test manual, the expert panel was unanimous that the MABC-2 contents/items were representative of the motor domain it was intended to evaluate.

The Beery-Buktenica Developmental Test of Visual-Motor Integration, Sixth Edition

The Beery-Buktenica Developmental Test of Visual-Motor Integration, Sixth Edition (The Beery VMI: Beery and Beery, 2004) is a norm-referenced test most widely used by occupational therapists to assess visual-motor integration in populations aged from two years old and above (Brown, Rodger, Brown, and Roever, 2007; Feder, Majnemer and Synnes, 2000). Visual-motor integration is an important component in children's development and it is linked to many functional skills, the ability to participate in daily tasks and the overall sensory-motor development (Marr and Cermak, 2002). The test has full and short formats about visual-motor integration (about 15 and 10 minutes each) but also has two supplemental tests on visual perception and motor coordination (about five minutes each). Motor coordination in Beery VMI, is measured through writing skills and it was an element that the researcher did not see relevant to her study, so she decided to use the supplementary test of visual perception. In this test the individual is again presented with a series of progressively complex geometric images. However, in this subtest the examinee is asked only to identify each item's identical match from a set of similar shapes. This timed subtest provides us with information on how the visual system specifically is perceiving the information it receives. The scoring of the test is as follows: >129 Very high, 120-129 High, 110-119 above average, 90-109 Average, 80-89 below average, 70 -79 low, <70 very low. Average can also be defined as one standard deviation above and below the mean, which would be standard scores of 85-115. Visual perception plays a crucial role in the development of body awareness, balance and planning skills (Ayres, 1972), which are the skills the researcher is focusing on in her thesis, so it was important for the children not to present difficulties in this test. This was to ensure that any difficulties in sensory-motor skills were related to the sensory processing of them rather than poor visual perception. Hence, the score needed to be anything above 79, which is the cut-off for low visual perception.

The Beery VMI was standardized on a national sample of 1,737 individuals age 2 to 18 years and 1,021 adults ages 19-100. It has high content and person reliability, with total group item separation of 1.00 and total group person separation of .96. The VMI's interscorer reliability for the children's norming group is .93. No studies have established validity for the sixth edition of the VMI, although concurrent, predictive, and content validity were established for previous versions (Pfeiffer et al., 2015).

4.10.3 Staff Participants

As mentioned previously, during the data collection of the intervention group there were two autism units at the school. These two units had two teachers and three teaching assistants. For the staff in the classroom, the only inclusion criterion was to be working in the specific classroom either full-time or part-time and to know the children for at least two months. When the researcher visited the school she had a meeting with the two teachers explaining to them the aims and the methods of the study. Then they presented this information to the teaching assistants without the researcher being there. Following that, the researcher had discussions with all staff members to ensure they understood the process and to give them an opportunity to raise any concerns or questions. Consent forms for all the member of staff were provided (see Appendix 2). Both teachers and one teaching assistant agreed to participate, however, just before the pre-intervention phase the teaching assistant had to withdraw from the study for personal reasons. Her decision was respected following the BERA (2011) ethics principle that research participants have the right to withdraw at any point of the study if they wish. Therefore, the two teachers formed the final sample reporting on the intervention group (completing the assessments and the interviews).

As mentioned previously, there were two autism units at the school during the data collection from the intervention group. The following year, a third autism unit was created at the school. This unit had a teacher and a teaching assistant. As before, the only inclusion criterion for the staff was to be working in the specific classroom either full-time or part-time and to know the children for at least two months. The researcher visited the school and explained to the classroom teacher the purposes of the study and the use of a wait-list control group. Then she presented this information to the teaching assistant without the researcher being there. Consent forms for all the members of staff were provided but only the classroom teacher agreed to take part in the study as the teaching assistant had a very busy schedule overseeing two different classrooms. Therefore, only the classroom teacher participated in the study by completing the assessments for the children in the control group but did not take part in an interview.

Table 1: Information on all children participants

	Participants	Age (in years and months)	Gender	SCQ	Raven CPM grade	BPVS STD score and age equivalent	SSP-Movement Sensitivity	MABC-2 Total score traffic light	Beery-VMI-Visual perception
Intervention group (N=5)	1	4:08	Male	22	III (1)	98, 4:05	5	Red Zone	95
	2	5:00	Male	23	IV (3)	92, 4:08	6	Red Zone	83
	3	5:10	Male	24	IV- (4)	86, 5:00	8	Red Zone	92
	4	5:10	Male	25	IV (3)	91, 5:03	10	Red Zone	90
	5	5:08	Male	27	III- (2)	90, 5:00	7	Red Zone	86
Control group (N=5)	6	5:05	Male	25	IV (3)	95, 5:01	7	Red Zone	86
	7	5:02	Male	22	III- (2)	99, 4:11	7	Red Zone	93
	8	4:00	Female	25	III (1)	100, 4:00	6	Red Zone	86
	9	5:01	Male	23	III- (2)	97, 4:11	8	Red Zone	89
	10	5:08	Male	24	IV (3)	91, 5:01	9	Red Zone	90
Intervention group Mean, SD		5:04, 6.42		24.20, 1.92		91.40, 4.34 58.40, 3.91	7.20, 1.92		89.20, 4.76
Control group Mean, SD		5:06, 7.66		23.80, 1.30		96.40, 3.58 57.60, 5.46	7.40, 1.14		88.80, 2.95
p		0.49		0.72		0.15, 0.82	0.83		0.91

Note: Significance (p), mean and SD were calculated using the t-test formula

4.11 Summary

This chapter made reference to what a study design is and how this can be influenced by the philosophical worldview of a researcher. Then, the researcher presented her philosophical view, which was the pragmatist or mixed methods and what this meant for her study design. Additionally, the researcher presented the reasons that a mixed methods designs are used and which types exist so as to justify the choice of her type of research design that was a partially mixed sequential dominant status design (Leech and Onwuegbuzie, 2007). She then presented the aims of the study and the research questions, explaining how a mixed methods approach would better help her answer them, although there have been criticisms of its use. She also gave information about the methodological approaches she chose to answer her research questions. It is suggested that although qualitative studies can provide valuable insights into the process of change and enhance understanding of different aspects of learning, experimental group designs remain the most powerful method available for assessing intervention effectiveness (Vockell and Asher, 1995; Gersten et al., 2005). The researcher focused mainly on experimental paradigms in this study, but she tried to develop and implement them in response to real-world concerns about the education of students with autism (Gersten et al., 2005). Furthermore, the researcher described the sample and the setting of the study and concluded with a table describing the process and the different stages of the research. The next chapter provides a sequence of the study implementation, describes Pictogram Room and the way in which the intervention was conducted. Furthermore, it describes the methods of data collection, the validity and reliability of the study and ethical concerns.

CHAPTER 5

METHODOLOGY: INTERVENTION DESCRIPTION AND RESEARCH METHODS OF THE STUDY

5.1 Introduction

Chapter five starts by presenting the sequence of the study implementation. This is a simple description of all the stages, as more information is given in the relevant sections of the chapter. Then there is a description of Pictogram Room and of the activities within it. Following that, the implementation of the intervention is presented, as well as the fidelity check that the researcher followed. Later, the methods of data collection are presented, that included: i) video recordings of the children ii) standardised assessments and iii) interviews with the school teachers. The chapter then discusses the validity and reliability of the study and presents the way in which the data was analysed. It concludes by making reference to the ethical concerns of the study.

5.2 Sequence of study implementation

The study took place over the course of two academic years (See Table 2). At the beginning of the first year, the researcher conducted some pilot testing. This testing involved observations of the children in the school and of activities that were taking place there. This was so that the researcher was able to familiarise herself with the environment and have the chance to conduct informal interviews with the teachers about the study. These informal interviews helped the researcher to identify two children that she could pilot the software with. During these stages of the pilot, video recordings took place and the Balance, Body Awareness and Planning (BBAP) checklist was developed by the researcher to code the videos of the children in various school environments. In addition, the researcher, along with the teachers, decided on the activities from Pictogram Room that would be used for the development of children's sensory-motor skills.

After this piloting, the researcher conducted assessment with the children who were referred by the teachers as having sensory-motor difficulties, to finalise the intervention group, which consisted form five children. Following that, the researcher collected the data that served as the pre-intervention assessments. Then, she implemented the intervention with the five children. After the end of the intervention, post-intervention data collection took place. Additionally, the researcher conducted a pilot for the teachers' interviews that would follow next. When she conducted the interviews with the teachers, new insights emerged regarding improvements in social play and adaptive behaviour skills in the intervention group. Therefore, a new research question was added to the study.

In the second year, the researcher went back to the school to recruit a wait-list control group for the study. Similar procedures to those used to identify the intervention group, were followed to identify the wait-list group. However, over the duration of the intervention for the intervention group, the control group received intervention-as-usual. When this period was completed post-intervention assessment took place for the control group. Additionally, as a new research question had emerged from the teachers' interviews, two new assessments were added, the Social Play Assessment (SPA) developed by the researcher, and the Vineland Adaptive Behaviour Scales-II: Teacher Edition (Sparrow, Cicchetti and Balla, 2005) as pre- and post-intervention assessments. It is important to note, that the same videos that were collected from the intervention group during the first year, were used to code social play behaviours.

Table 2: Stages and actions of the study

Timeline		Stage	Actions
Year 1	October 2012 - December 2012	Pilot 1 (2 weeks)	Observation of children and activities taking place throughout the school. Informal interviews with teachers about the piloting of the software to identify the children.
		Pilot 2 (4 weeks)	Video recordings of the two children in different school environments, such as corridors, physical education, classroom, playground, assembly room, lunch room. Video recordings within the software environment across all 40 activities of Pictogram Room (two sessions a week for four weeks). Development of Balance, Body Awareness and Planning (BBAP) checklist from the researcher to code the video recordings.
		Pilot 3 (1 week)	Decision on the Pictogram Room activities with the teachers. Decision on the environments of video recordings and modifications of BBAP.
	February 2013 - July 2013	Pre-intervention 1 (1 week)	Data collection from children for sample description. Finalising the intervention group
		Pre- intervention 2 (2 weeks)	Conducting pre-intervention assessments and video recordings across physical education, playground, and classroom.

		Intervention (10 weeks)	Two sessions per week for 10 weeks with Pictogram Room. The first two sessions were familiarisation activities, so the actual intervention was lasted nine weeks.
		Post-intervention 1 (2 weeks)	Conducting post-intervention assessments and video recordings across physical education, playground, and classroom.
		Pilot 4 (1 week)	Piloting the teachers interviews
		Post-intervention 2 (1 week)	Conducting the interviews with the two teachers of the intervention group. New insights emerge and a new research question is formed.
Year 2	March 2013	Pilot 5 (2 weeks)	Development of Social Play Assessment (SPA) checklist from the researcher to code the video recordings.
	April 2013 - July 2013	Pre-intervention 3 (1 week)	Data collection from children for sample description. Finalising the control group
		Pre- intervention 4 (2 weeks)	Conducting pre-intervention assessments and video recordings across physical education, playground, and classroom.
		Intervention (10 weeks)	For 10 weeks the control group continued intervention-as usual.
		Post-intervention 3 (2 weeks)	Conducting post-intervention assessments and video recordings across physical education, playground, and classroom.
	July 2013 - September 2013	Post-intervention 4	Control group receiving intervention (interrupted because of summer holidays and some children changed teacher or left the school)

5.3 Description of Pictogram Room

Pictogram Room is a set of video games for children and adults with autism and is free to use. It utilises augmented-reality to help individuals understand pictograms creating a virtual space with highly customisable educational activities. This virtual space includes more than 90 activities, developed by a multidisciplinary team with experts from education, psychology, computer vision, computer music and augmented reality. The areas targeted through these activities include: body schema, postures, joint attention, imitation, communication and relationships. Through a system of camera-projector, and through the recognition of movement, it is possible to reproduce the image of the player himself or herself augmenting with a series of graphic and musical elements that guides the learning process. All the games can be adapted to the preferences of each student (Herrera et al., 2012). For example, they can be customised in line with each student's visual or musical preferences.

5.3.1 Operating System

To use the software, a PC or laptop with Windows 7 or Windows 8 is needed, the Kinect Sensor and an area of projection (television, screen or wall). In order to use this tool, a large space is required, measuring at least 3 x 3 meters in front of the projector or screen on which the images are to be shown (see Figure 1). It is also advisable to use an open plan room, or one with few distractions, at least, as this may divert the children's attention during the games. It is recommended by the developers to use the largest screen or projection surface possible, even covering an entire wall, as too small an area may result in users getting too close to it and might therefore not see the images correctly, and the system will not work properly. More details on the technological hardware and software requirements for using this tool correctly can be found online at www.pictogramas.org. It is advisable to disable any screen savers while using the Pictogram Room, to prevent the dynamic of the game being interrupted.

Figure 1 Pictogram Room set up Example

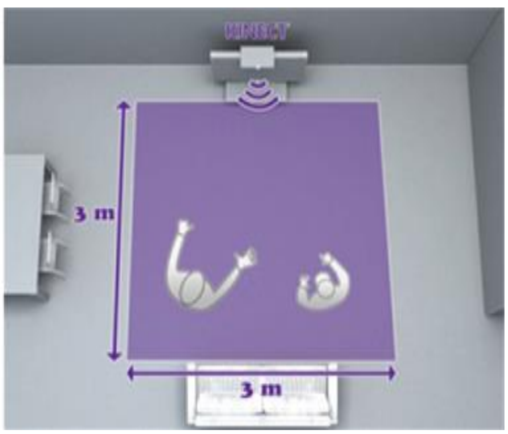
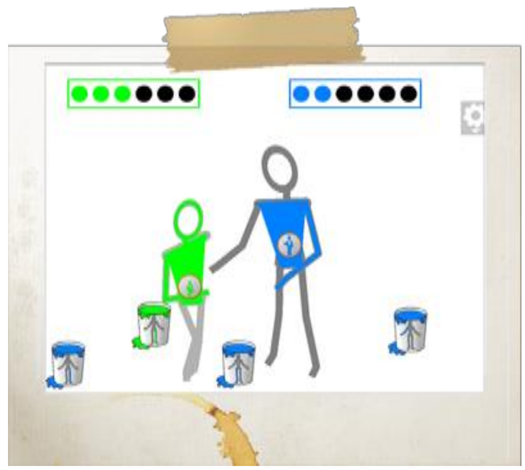


Figure 2 Pictogram Room Activity



5.4 Description of activities

Pictogram Room encompasses four sets of activities, which are: The Body, Positions, Pointing and Imitation. For the purposes of this study, the two categories of activities selected were The Body and Positions, as they were specific to sensory-motor skills. More specifically, the activities under these categories aim to assist in the develop children's body awareness, motion and balance skills. Also, the activities require a set of steps for completion, which are related to body movement; thus they also tackle planning skills. All the activities include a progress marker at the top of the screen. Each time an exercise is completed, a new dot on the marker is filled in, showing the student's progress and the number of tasks remaining for each activity (See Figure 2 for an activity example). This progress marker provides a constant visual and predictable aid for the student with autism assisting with beginning and end of an activity, as well as sequencing and transitioning to the next activity (Dettmer et al., 2000). Below there is a description of the activities included under the categories Body and Positions and a table (Table 3) with the sets and the games under these categories.

5.4.1 The Body

This first category of games includes activities designed to help individuals with autism with the development of recognition of the body. These are “mirror” games, where the student gradually increases his or her attention to different parts of the body. In this category there are four sets of games with four activities in each, which are described below.

Set 1: Movement

This is a set of games for working on the cause-effect relationship between spatial movement and the playing of music and visual effects. Arrows appear on the screen indicating the areas in which the student has to move in order to trigger certain visual or musical effects. Each time the student enters one of the illuminated areas and remains there for the time indicated, a dot on the progress market is filled in.

Set 2: Touching

In this set of activities the cause-effect relationship is developed in more depth by focusing the student’s attention on a key part of the body, such as his or her hands. As with previous activities, in this game the background picture is a video image that creates a mirror effect, and the results of touching different items are music or video effects.

Set 3: My photos

These activities are designed for the student to learn to identify his or her own image and differentiate it from that of others through photographs. The first activity requires both the student and the other player (e.g. another student, parent, researcher etc.) to take a picture of themselves. These photos are also used in the other activities in this set, where the student has to learn how to choose the photos by touching them with his or her hand.

Set 4: My doll

These activities are aimed at revealing the stick puppet, or the pictogram as it called in the game, for the first time. It is shown over the top of the human figure, for the student to become familiar with the pictographic representation of his or her body. The “Making music” activity is one of those which uses this representation. Here, the student can create music by placing his or her hands in the strip shown on the screen at all times. The initial setup shows the student puppet in green and the other player’s puppet in blue. Two different colours are used in order to help the student differentiate correctly between the two puppets. These colours can be customized, through the application website, to use the student’s favourite colours.

Set 5: Parts of my body

To complete this set of games, the student first has to notice the different parts of his or her puppet, shaking them as shown on the screen. In these games, the student and the other player have to move quickly, and identify the correct parts of the body as presented in the screen. When they do, this part of the body is painted with green or blue, depending on the player.

5.4.2 Positions

The games under positions category are intended to take the development of the human body one step further, working on posture and movement imitation games. During the posture games, the intention is for the students to gain more and more awareness of their bodies, and learn to differentiate between different postures as they start to adopt them. This group of games requires better movement skills and balance on the part of both players. Just as in the other set of games, all these activities can be completed alone or in collaboration/competition with the tutor or another student.

Set 1: Positions by parts

This first group of activities has been designed for the student to practice copying body postures based on a static model. The first task requires copying part-by-part (first an arm, then a leg, etc). The second and third activities require copying with half the body (both arms, both legs or one leg and one arm). In the last activity the posture must be copied using the entire body.

Set 2: Shapes

In this group of activities, the student has to adapt his or her body posture to fit inside a number of different geometrical shapes. First of all, he or she has to get into the different spaces on the screen ("gaps" exercise). In these activities there is no need to copy any particular posture, but adopt one which makes them fit into the required space. In the second exercise ("Dodging"), these spaces are moving and the user has to position himself or herself so that they do not bump into them. In the last two activities ("Hold in the Wall" and "Jigsaw"), the gaps take on much more complex shapes, requiring the student to make more precise movements.

Set 3: Different positions

This set of games are for working on overall perception of postures and memorisation. The student must identify a posture from a selection on offer, observe the overall aspects of the posture and then remember them in order to copy or find it. In the activities "Remember the posture" or "Find the posture" the student first has to copy a sample posture shown on the left, and, having stood over it, must then find it among the dots on the right. These activities are also intended to encourage attention to overall features, compared with small details, which is the natural tendency for many people with autism (Hill, 2004). For this reason, the activities may be particularly challenging. The other two activities ("Find postures" and "Find more postures") start out in a similar way, in that the student first needs to copy the posture on the left. The second step then requires the student to find the posture he/she has just copied from those shown on the right.

Set 4: Sequence of positions

This set of activities is included to help the student to learn a sequence of movements, serving as a basis for learning more complex issues regarding taking turns and motor-planning. The different activities use a visual guide to show the posture adopted, either at the top of the screen, or over the puppet on the screen. For example, in the activity “My turn”, the student must raise his or her hand when the right color puppet does so on the guide at the top of the screen. One sequence of postures which reflects a communicative situation is the “Hello and Goodbye” activity, where the student has to complete a number of ‘greeting’ movements (hand shaking) and end with ‘goodbye’. This learning process in the Pictogram Room helps the student to a series of social routines.

Set 5: Moving positions

Finally, this group of “Postures” activities ends with a set of games in which the student must maintain a posture while moving from one side of the screen to the other in order to progress a level. For example, in the activity “Carrying balls”, the student has to place his or her arm in a certain posture and hold it while moving to one side to stop the ball from dropping, thus completing the task. In this activity the ball is easily dropped and it can be frustrating. However, during the tests completed with the tool prior to release, we have seen how the fact that the students enjoy these activities translates into an unusual tolerance of such mistakes which was surprising to both tutors and families of the students.

Table 3: Activities in Pictogram Room

Category	Set	Activity/Game	Category	Set	Activity/Game
Body	Movement	movement with lights	Positions	Positions by parts	Arm or leg
		movement with music			Arms or legs
		movement with lights or music			Half body
		movement with lights and music			Whole body
	Touch	Touch with your hand		Shapes	Gaps
		Touch here and there			Avoid
		Follow and touch			Hole in the wall
		Choose and touch			Jigsaw
	My photos	Taking photos		Different Positions	Remember the position
		Choosing my photos one by one			Find the position
		Choosing my photos nonstop			Fid the positions
		Photo shower			Find more positions
	My doll	Move the doll		Sequences of Positions	Musical passage
		Make music			My turn
		Touch the photo and the doll			Goodbye
		Doll shower			Hello and Goodbye
	Parts of my body	Parts of my body		Moving positions	Push
		Parts of my doll			Carry things
		Colour my doll			Carrying large things
		Colouring shower			X-rays

5.4.3 Piloting of the software

Pictogram Room was piloted with two children (Table 2; Stage: Pilot 2) for a period of four weeks. They were both boys aged 7:02 and 7:05. The children had two sessions a week using all 40 activities (five activities per session). At this stage the teachers were present, alternatively if they were busy, they would watch the video recording afterwards so as to decide which activities might work best. Of the 40 activities eight were excluded for various reasons. Three of these activities, in the Body category (i.e. touch here and there, follow and touch, choose and touch), were not working properly and were getting stuck. Also, five activities were excluded from the Positions category. Two of those were from the Shapes set (i.e. Hole in the wall, jigsaw) because the teachers thought that they could potentially be overwhelming for some of the children due to the colours and shapes presented. The other three, were in the Sequences of Positions set (i.e. my turn, goodbye, hello and goodbye) because they were not working properly. Of the 32 remaining activities, two were also excluded from the analysis of the main study as they were used for the familiarisation period, which is going to be described in more detail in the next section. These two activities were from the Body category, from the Movement set (i.e. movement with lights, movement with music).

5.5 The intervention procedure

The children used Pictogram Room for a total of ten weeks having two sessions per week for 15 minutes each. The first two sessions (Week 1) were familiarisation sessions using games that were not used for the main intervention period, which was nine weeks in total. The familiarisation sessions were very important, as the children were introduced to a new software that they had not used before, therefore the researcher wanted to make this transition easy and gradually make them feel confident using it. The activities that were used for this purpose were very simple allowing the children to be introduced to the actual environment in a smooth way. It also allowed them to familiarise themselves with the dot system, as explained previously. In addition to that, because not all children in the same classroom could be involved in the study due to its purposes, it would not be ethical to exclude them from a material that was in their environment. Therefore, sessions with Pictogram Room took place in another classroom within the school. As a result, part of the familiarisation process involved the children coming to a new classroom and feeling comfortable doing so. Finally, the children were using Pictogram Room with the researcher as the other player and all sessions were video recorded.

The children completed 30 activities in total targeting balance, body awareness and planning skills, across six sessions. Therefore, the children were playing five different games in each session. The activities for every session were predetermined and always following the same order. The same 30 activities were used for the next six sessions and for the last six sessions, in the same way as in the beginning. This practice would assist in the coding process, which is going to be described later on, allowing the researcher to see the differences in children's sensory-motor skills at the beginning and at the end of using the software, while using the same set of activities. Consequently, the researcher had to ensure that this order would be followed and always had a schedule with her with the activities. Also, a fidelity of implementation check was developed, which is going to be described next. Although for the purposes of the study the children followed the same activities, the researcher tried to personalise them to better fit each student's needs. The personalisation was mostly regarding to the sound and the colours in the game. For example, some children did not want sound during the games and some other children preferred to listen their favorite songs during game play.

5.5.1 Fidelity of intervention implementation

Ensuring fidelity of implementation is a very important element for producing good quality research (Jones and Jordan, 2008) and for this reason it was taken into serious consideration in this research study. Kasari (2002) suggests the use of fidelity checks to determine whether the intervention was conducted in the way it was supposed to. There are many ways of checking research fidelity and these can be divided into two large groups; internal and external ways of checking fidelity of implementation (O' Donnell, 2008). For example, in external fidelity check, one could ask a trained person to observe and comment on the extent to which the researcher followed the guidelines or the principles of an intervention and rate this. On the other hand, internal checks can either take place from a person participating directly in the study, or from the researcher himself or herself. For the purposes of this study the fidelity was checked internally and more specifically by the researcher. As the fidelity of implementation was regarding practical implementations (e.g. timing, order of activities, classroom arrangement) rather than ratings (e.g. giving a score) and also there were video recordings of the sessions, it could be implemented by the researcher herself.

Therefore, for the calculation of the fidelity of implementation, percentages were used. As mentioned before, the fidelity concerned timing and order of the activities and classroom arrangement. The researcher coded all sessions with Pictogram Room for fidelity. The timing of the activities was calculated by using how long the activities adhered to the time schedule. The result indicated that the timing was followed at 109.3% meaning that the overall time exceeded the scheduled time by 9.3%. The order of the activities was 100% meaning that at every session the scheduled activity order was followed. Finally, the classroom arrangement was 100% meaning that in every session the laptop, the Kinect camera, the desks and the chairs in the classroom were kept in the same position.

5.6 Methods of data collection

To collect the data the researcher used a combination of quantitative and qualitative methods. To begin with, she conducted observations through video recordings of the participants and she developed two checklists. The first one, Balance, Body Awareness and Planning (BBAP) was used to code children's sensory-motor skills and the second one, Social Play Assessment (SPA) was used to code children's social play, which was one of the skill set that emerged from the teachers' interviews about the intervention group. Additionally, parents and teachers completed standardised assessments (see pages 160-165 for more details on the standardised assessments), the Sensory Processing Measure (SPM: Parham et al., 2007) and teachers also completed the Vineland Adaptive behaviour Scales-II (VABS-II; Sparrow, Cicchetti and Balla, 2005). All of these were quantitative methods of data collection and helped the researcher answer the first three research questions of the study (i.e. BBAP and SPM) and the last research question that came up from the teachers' interviews of the interventions group (i.e. SPA and VABS-II). Also, the researcher conducted interviews with the teachers of the children in the intervention group. Through this qualitative method the researcher answered the fourth research question of the study, regarding the ways Pictogram Room can be used in a school setting. It also helped to obtain a more holistic picture of the data collected through the quantitative assessments regarding the first three research questions of the intervention group results. Below there is a description of these research methods. The section starts by describing the observation procedure through the video recordings and their coding. Then there is a reference to the second group of quantitative research collection methods, that of the standardised assessments. Furthermore, there is a description of the interviews conducted with the teachers.

5.7 The observation and the researcher's role

Observation is the systematic noting and recording of people, events, objects, setting and so on (Robson, 2002). Before carrying out observations there are several factors to take into account. To begin with, one very crucial aspect is the degree of structure. Therefore, an observation may be highly structured, semi-structured or unstructured (Cohen, Manion and Morisson, 2011). Another key issue is the role of the observer. Gold (1958, cited Cohen et al., 2011) describes different observer roles as follows:

1. complete participant (observer takes an insider role as a member of the observed group),
2. participant-as-observer (while participating in activities, the observer can ask the participants questions to clarify what is going on),

3. observer-as-participant (the observer does not take part in the activities but his or her status as a researcher is known to the participants) and
4. complete observer (participants are not aware that they are being observed).

Highly structured observation was chosen as the most appropriate method of answering the research questions and the researcher had the role of the participant-as-observer to carry out the study. This type of observation follows the example of studies that previously have been done in the field (Fertel-Daly et al., 2001; Cox et al., 2009; Bonggat and Hall, 2010). One of the key strengths of observations is the directness of the data, which means that the researcher does not ask the participants for their views but she is there, watching what they do and listening to what they say (Robson, 2002; Cohen et al., 2011). Additionally, conducting observations is a way to get information about individuals who are unwilling or unable to take part in interviews and questionnaires (Creswell, 2003). In this study, observations were chosen in order to get powerful insights into a situation and give information about behaviours that interviews and questionnaires cannot. Moreover, children's communication difficulties, and their young age, would make it impossible for them to participate in such a form of assessment as in interviews and questionnaires.

There are some limitations, on the other hand, that the researcher tried to overcome. The presence of the researcher was likely to have an effect on children so her goal was to keep this effect to a minimum. Therefore, she tried to become an 'undercover agent' (Denscombe, 2010, p.206). This was mainly achieved by the volunteer work the researcher conducted at the school much before the study and stayed till the end of the year. As the researcher was bringing the camera in the school (without recording in the beginning) after a while children did not notice that she was using it. The fact that data coming from observations is often ‘content limited’ (Webb et al., 1966, cited Lee, 2000), is a third limitation, meaning that the researcher is bound to the data she sees. Children sometimes had good days and at other times they had bad days. Efforts were made by the researcher to minimise the weaknesses of observations. The use of a structured observation scheme, accompanied by a detailed list of definitions for each category being observed, was one method of dealing with the problem of the researcher’s subjectivity. The use of a video camera, which would give the researcher more time to think before rating children’s behaviours and allowing inter-observer reliability checks, is another way to handle this limitation. Given that the researcher worked directly with the children, this could have made her biased. To minimise the likelihood of this, inter-rater reliability of the video recordings took place as well as the use of other methods of data collection to triangulate the data from the observations.

5.7.1 Video recordings of the children

It is not always easy to observe all the actions a child performs. Having a video recording allows the researcher to perform multiple viewings of the data set. It also allows other raters to view the videos and perform checks, which make the reliability process much easier (Heath et. al, 2010). In this study, data of different aspects of behaviour was needed (e.g. behaviours regarding body awareness) and this makes it hard for the observer to remember or notice all these behaviours when they happen and code them at the same time. Having the videos allowed the researcher to go back and analyse the data more carefully. Moreover, it gave the opportunity to teachers to see how children worked during the implementation of the intervention and the researcher to provide the videos to other raters for reliability check.

Video recordings have a number of strengths and limitations. Perhaps the greatest advantage of video recordings is its openness to scrutiny (Heath et. al, 2010). Different raters can code the same video to increase reliability. Moreover, they can go back to the video several times increasing accuracy in coding (Heather, 2010). Furthermore, compared to other methods of data collection, videos have a 'longer shelf life' (Stigler et. al, 2000, p.4). This means that existing videos can be used for re-coding and re-analysis to test new theories and/or compare new findings to previous ones. Consequently, videos can be used by a different number of researchers, even when they come from different fields, and in this way promote interdisciplinary research (Stigler et al., 2000). For example, software engineers might develop new software for children with autism but educators or psychologists conduct the fieldwork. Moreover, video recordings can promote reflection as the researcher or the participants can go back to the video and learn from their actions and change their practices (Kennedy, Landor and Todd, 2011). For example Kossyvaki, Jones and Guldberg (2014) used video recordings to allow teaching staff to reflect on the practices they used with their students with autism to elicit spontaneous communication.

Although video recordings have these strengths they have some limitations as well. Video data can be limited to what the researcher observes (Heather et. al, 2010). This is something that the researchers need to bear in mind when watching the videos and analysing data. Additionally, video recordings can be lengthy and can require many hours of watching and coding (Stigler et al., 2000). Also, it is important to note what Stigler et al. (2000) point out as the 'camera effect'. When participants know that they are video recorded they might have a different behaviour than the usual (e.g. feel more excited, feel embarrassed). Video might also raise some practical and ethical concerns. Practical issues usually include the placing of the camera, the number of cameras to be used, lighting and sound (Heather et al., 2010). Ethical issues concern obtaining consent forms from the participants and, especially in the case of the participants being young children, parents might feel threatened by someone having visual data of their child and this might lead them to not participate in the study (Derry et al., 2010).

For the purposes of this study, video recording took place at the children's natural setting and more specifically at their school (i.e. Classroom, Physical Education, Playground). This was more challenging for the researcher, as school is not an environment in which you can easily control variables, such as noise level and duration of a session as someone would in a lab setting. Naturalistic environments are suggested to be the most valid environments to observe the behaviour of children with autism (Clifford et al., 2010) and video recordings are highly recommended for analysing non-verbal behaviours, such as body language (Heath et al., 2010). Although it is important to get information from people directly working with the students, getting first-hand information by using videos can give the researcher direct data on what happens in practice (Cohen et al., 2011). As the researcher wanted to also check the generalisability of the results outside the software environment, video recordings took place in children's natural environments. More details on these environments are given in the next section.

5.7.2 The environments of video recordings

As mentioned previously video recordings took place for both the intervention and the control group. In four out of five environments video recording took place. These were:

1. The Software
2. The Classroom
3. The Physical Education (PE) and
4. The Playground

Home was not included as it was not feasible for the researcher to visit the children's homes and it was not feasible the parents to take on such work. However, four environments for video recordings could provide enough data on the effects of the intervention. This also follows the recommendation on the Social Communication Emotional Regulation and Transactional Support (SCERTS) model (Prizant et al., 2006). The authors of the SCERTS model recommend that assessment of a child's behaviour at baseline should take place in a range of environments, varying across at least four of the following pairs of characteristics: structured versus unstructured, must do versus fun, adult-directed versus child-directed, motor-based versus sedentary, familiar versus unfamiliar, preferred versus non-preferred, easy versus difficult, language-based versus non-language-based, social versus solitary and busy versus calm. These variables might influence children's behaviour in different environments/activities and this is the reason they should be taken into account (Prizant et al., 2006). The intervention therefore took place (software environment) is a calm environment, structured, fun, motor-based and adult-directed. PE is very similar although it is a quite busy and noisy background. The classroom is more sedentary and a 'must do' environment and the playground is a child-directed and unstructured environment. In regards to the classroom environment, the researcher used video recordings of more unstructured activities (e.g. play time in the classroom) rather than recordings from the academic activities. The reason for that was that during the purely academic activities it would not be expected to see physical activity and social interactions by the children to a great extent, as they would be sitting down.

5.7.3 Duration of video recordings

The authors of the SCERTS model (Prizant et al., 2006) suggest that to get representative data, it is important to observe each child for at least two hours in each environment. They also advise that it is better if the videos are not taken in the same day, but at least at two different days. In this study, each of the five children were videotaped for one and a half hours across each environment. The decision was based on the duration of the work on the software environment, as the children needed this amount of time to complete the first set of 30 activities (six sessions). This duration was pre- and post-intervention with a total of three hours of observation for each child across all environments. This was a very long period time of video recordings, so it was split in different days of 15 minutes of video recordings for playground and classroom environments and different sessions lasting 30 minutes for PE and 15 minutes for the software. Table 4 shows the number and length of video recordings taken across the four environments for each child pre-, post- intervention and during intervention. It is important to note that besides the software environment, that there were no video recordings of the control group, for the other environments they have the same video recordings.

Table 4: Length of observations

	Pre-intervention		During Intervention		During Intervention		Post-intervention	
Timeline	2 weeks		Session 1-6		Session 13-18		2 weeks	
Environment	Length of each session videoed (mins)	*Number of sessions videoed over a 2 week period*	Length of each session videoed (mins)	*Number of sessions videoed over a 3 week period*	Length of each session videoed (mins)	*Number of sessions videoed over a 3 week period*	Length of each session videoed (mins)	*Number of sessions videoed over an 2 week period*
PE	30	3	N/A	N/A	N/A	N/A	30	3
Classroom	15	6	N/A	N/A	N/A	N/A	15	6
Playground	15	6	N/A	N/A	N/A	N/A	15	6
Software **(Not Applicable; N/A)**	N/A	N/A	15 N/A For control group	6 N/A For control group	15 N/A For control group	6 N/A For control group	N/A	N/A

5.7.4 The use of the video camera

A Panasonic HC-V100 Full HD camcorder was used for video recording. It was bought for this study on the basis that it was the best option (e.g. reliable, light, sound, zoom and good image quality) for a non-professional camera. Lonergan (1990) states that the quality of the sound, the level of lighting and the use of the zoom are key factors to consider. He highlights the drawback of using a built-in microphone and proposes the use of an extension microphone to get clearer sound. The use of an extension microphone was ruled out, as it would add extra weight and sound zoom was used instead. Moreover, the researcher had to decide whether or not to use a fixed position for the camera (Heath et al., 2010). Use of a tripod was decided for the video recordings in the room where the intervention took place, as the researcher had to move freely and, since the area was well structured, a fixed position did not prevent capture of all the necessary data. However, in the other contexts the researcher was holding the camera instead of using a tripod. This was because the children were continuously moving in a bigger environment and the researcher may have lost important data.

Filming was conducted at the highest possible resolution to ensure the best video quality. Optical zoom was adjusted before starting recording and it was kept steady to avoid degrading the quality. The camera operated with a memory card of 32GB capacity. At the end of each school day, the data was transferred through cable from the camera to the researcher's laptop and then to an external hard drive which was kept at all times in a safe place at the researcher's home.

5.7.5 Video Data Coding

As mentioned previously, there are different types of observational recording in which the degree of structure may considerably vary but for this study a highly structured way of recording (i.e. predetermined categorised recording sheets) (Cohen et al., 2011; Hopkins, 2002;) was chosen. When conducting a structured observation, the focus of the observations has been determined beforehand. This type of observation follows the principles and assumptions of quantitative research: the focus of the observation is fragmented into predetermined, smaller, more manageable pieces of information (behaviours, events etc.) that can be aggregated into variables (Cohen et al., 2011).

This section considers how the data captured from the video camera was coded. At this point there were a number of different decisions to be made. These included the amount of video to be coded and how the skills to observe would be categorised. Regarding the amount of video observations to be coded, it was decided to use all children's data for assessing sensory-motor skills. For the social play, 30 minutes of videos across each environment were chosen. These 30 minute segments were taken from the middle of the total 90 minutes (the first 30 minutes and the last 30 minutes were not coded). To categorise and code children's sensory-motor skills a highly structured checklist was developed by the researcher. This was the Balance, Body Awareness and Planning (BBAP) checklist. Similarly for social play she developed the Social Play Assessment (SPA). Both of these assessments, as well as their coding, are described below.

5.7.5.1 Balance, Body Awareness and Planning (BBAP) Checklist

As mentioned previously, for the purpose of this study an observation system was developed (Appendix 3). The development of the checklist was based on previous studies (Dunn, 1999; Pharham et al., 2007) mainly following the structure of the Sensory Processing Measure (Pharham et al., 2007). The checklist is a table, which includes sixteen items and these items are grouped into three categories. The first category contains eight items about balance and motion, the second one is about body awareness and consists of five items and the third one is planning and ideas and has three items. A definition was given for each item under these categories to be easier and more consistent for the reliability check and the interviews as it will be described further on (see Appendix 4 for the definitions). The items of each group are recorded in the same way that a Likert scale is carried out in other standardised assessments in the field, such as SPM (Parham et al., 2007) and Sensory Profile (Dunn, 1999) with four points. The scoring is described below:

0= The child **did not have the opportunity** to present the behaviour in question in the specific videoed context.

1= The child **consistently** demonstrated the behaviour in question in the specific videoed context.

2= The child **inconsistently** demonstrated the behaviour in question in the specific videoed context.

3= The child **did not** present the behaviour in question in the **specific** videoed context.

For further understanding, it is important to provide some information about the items included in BBAP and provide an example. All items in the checklist are negatively stated, for example, 'has poor coordination' or 'moves stiffly'. Therefore, the greater the score the child gets, it means that he or she performs better. If the child in the specific videoed context sometimes presents these behaviours and sometimes not, for example his coordination varies from being poor to being good then this would be scored as 2. Consequently, if the child always presents this behaviour will get a score of 1. The 0 score, is a not applicable behaviour. For example, there is an item in the checklist called 'difficulty to hop or stand on one foot'. If the child did not present this behaviour it might have been because he or she did not have this opportunity. An example might be in the classroom context where the child might be sitting down all the time. The range of the possible scores in the BBAP assessment is 0 to 144 for balance and motion, 0 to 90 for body awareness and 0 to 54 for planning and ideas.

Piloting BBAP

BBAP was piloted for three weeks. The aim of piloting the checklist was to construct a comprehensive observation schedule where the different categories were clearly defined and mutually exclusive. The observation schedule length, definitions of items and how to best code the videos were three issues which arose during the piloting. With regards to the content of the items and how they were defined, initially there were 26 items but the pilot trial revealed the weakness of some of these, Or the way in which they were defined was similar to other items and this was very confusing (e.g. seems lethargic and seems inactive). In terms of the coding, the researcher at the beginning was coding frequencies but during the testing of the checklist it was revealed that it was not easy and did not represent to a great extent the children's skills. So a Likert scale from 0 to 3 was used.

5.7.5.2 Social Play Assessment

As mentioned previously, for the purpose of this study a second observation system was developed (Appendix 5); the Social Play Assessment (SPA). The development of the checklist was based on previous studies on social play behaviours in autism (Holmes and Willoughby, 2005; Macintosh and Dissanayake, 2006). The checklist is a table, which includes three types of play and a neutral state. The types of play included here are: group, parallel and solitary. The researcher used this checklist to measure the frequency and also the duration that each child engaged in each of these types of play. Unfortunately, owing to time restrictions the researcher did not manage to pilot SPA.

For the social play the researcher developed the Social Play Assessment (SPA) to measure frequencies. For the video coding of the frequencies and the duration of social play in group, parallel and solitary play as well as neutral state, when the child did not engage into any form of play, a software programme called ELAN (ELAN, 2012) was used. The researcher had the chance to see this software while she was working as a research assistant in the ECHOES II project (Guldberg et al., 2010) and she thought that this tool would also be a good fit for her study. ELAN is a professional tool for the creation of complex annotations on video and audio resources. Although its published evidence come mostly from studies in linguistics and it is used more specifically to annotate gestures (Wittenburg et al., 2006), there are some examples of this software being used to code frequencies of observed behaviours from video recordings (e.g. Alcorn, 2013). There are many advantages to this software as, not only it is free to download, but also the researcher can more reliably note the beginning and end of a behaviour and thus have information on its duration as well. At the same time, the researcher can annotate a segment by writing a word description so that he or she will know what this annotated segment corresponds to. Finally, the data can be exported into an Excel format, which makes the analysis much easier.

5.8 Standardised assessments

5.8.1 Sensory Processing Measure

Description

The Sensory Processing Measure (SPM; Parham et al., 2007) measures sensory processing difficulties in children from the age of four years through twelve years of age. The SPM is a norm-referenced assessment that produces standard scores for praxis, social participation, and five sensory systems (visual, auditory, tactile, proprioceptive and vestibular function). The SPM promotes collaboration between parents and school personnel to identify sensory and environmental issues that may affect a child's performance across home, classroom and six other school environments (Art Class, Music Class, Physical Education Class, Recess/ Playground, Cafeteria, and School Bus). Three forms comprise the SPM; the Home Form, the Main Classroom Form, and the School Environments Form. The Home Form contains 75 items and is completed by the child's parent or primary caregiver. The Main Classroom Form is comprised of 62 items and is completed by the child's school teacher. The School Environments Form contains 10 to 15 items for each of the school environments (Henry, Ecker, Glennon and Herzberg, 2009). This form is completed by school personnel who are familiar with the child in the context of the environment being assessed. However, the School Environments forms are not standardised and they do not contain many items on balance, body awareness and planning development.

Administration and scoring

Each form can be completed in 15 to 20 minutes. Scores from the Main Classroom and Home forms are reported as T-scores and percentile ranks for each of the systems and functions listed above, as well an overall T-score; results from the School Environments forms (downloaded from an unlimited-use CD) are interpreted in terms of cut-off scores. For each scale on the SPM scores fall into one of three ranges: Typical, Some Problems, or Definite Dysfunction. The Environment Difference score provides a comparison of sensory functioning at school and at home. For the purposes of this study the Home form was completed by the children's parents before and after the intervention period and the main classroom from was completed in the same way by the children's teachers.

Standardization, reliability and validity

The SPM – Home Form and the SPM – Main Classroom Form were standardised on a sample of 1051 typically developing children aged between 5-12 years. Internal consistency and test-retest reliability data after 2 weeks for the Home Form were reported as 0.77 to 0.95 and 0.94 to 0.98 respectively which Miller-Kuhaneck further established in their study (Miller-Kuhaneck 2007). For the main classroom form internal consistency scores ranged from 0.75 to 0.95 and test-retest estimates after 2 weeks ranged from 0.95 to 0.98 (Parham, et al., 2007). In regards to validity, content validity was established through use of expert review panels and factor analysis was used to provide evidence of SPM scale construct validity (Parham et al., 2007).

The SPM demonstrates sound content, face, and construct validity. The authors of the SPM took measures to ensure the content and face validity of the current SPM items and scales (Miller-Kuhaneck 2007, Parham 2007). The author reports that "each SPM scale represents a theoretical construct that is defined by its item content and secondly, the scales can be scored and interpreted separately from one another," assuring construct validity (Parham 2007). The structural validity of the Home form is stronger than that of the Main Classroom Form (Parham 2007). The authors provide factor analysis data to further establish the SPM's structural validity. SPM scales appropriately distinguished between a normative sample and a sample of clinic-referred children with sensory processing difficulties indicating strong discriminant validity (Asher 2007, Parham 2007).

Vineland Adaptive Behaviour Scales-Second Edition (VABS-II)

The Vineland Adaptive Behaviour Scales-Second Edition (VABS-II: Sparrow et al., 2005) scales are available in three formats. Firstly, there are two survey forms; the survey interview form and the parent or caregiver rating form. These forms assess the four broad domain areas: communication, daily living skills, socialisation and motor skills. Also, there is an optional scale that measures maladaptive behaviours. The two forms are identical except for the way they are administered (either interview or rating scale). Secondly, there is an expanded interview form that measures the broad domain areas and also provides a basis for developing educational or other intervention programs. Finally, there is a teacher rating form, which measures the four domain areas mentioned previously, but as the teacher sees the behaviour occurring specifically within the educational setting. This form also includes items related to academic functioning. The teacher rating form is for students aged three to 21 years 11 months and it takes about 30 to 60 minutes to complete. This is the form that the researcher used for this study. Initially, it was selected to be part of characterising the participants, but after the teachers' interviews about the intervention group, the researcher decided to use it as a pre- and post- intervention assessment in both groups.

Standardisation, reliability and validity

The VABS-II was standardized using a nationally representative American sample of 3,695 individuals from birth to 90 years. The norm sample was stratified according to demographic variables such as sex, race/ethnicity, socioeconomic status, and geographic region. The researchers also controlled for community size and special education program placement. Data for norming and standardisation were collected on eleven clinical groups: attention deficit/hyperactivity disorder, autism-nonverbal, autism-verbal, emotional or behavioral disturbance, deafness/hard of hearing, learning disability, cognitively delayed-mild (child and adult samples), cognitively delayed-moderate (child and adult samples), cognitively delayed severe/profound (adult sample) and visual impairment.

A split-half reliability test determined the reliability of scores for two halves of the test using the standardisation sample data. The spearman-brown formula was used to determine correlations of the domains and subdomains. Across the age groups, the communication domain correlations ranged from .84 to .93. For the Daily Living Skills domain correlations ranged from .86 to .91. The Socialization domain ranged from .84 to .93. The Motor Skills domain ranged from .77 to .90. The Maladaptive Behavior Index demonstrated internal consistency coefficients ranging from .85 to .91 across age groups. Data from 152 individuals were used to determine interrater reliability. Average correlations ranged between .71 to .81 across domains/subdomains and ages. The Maladaptive Behaviors Subscales and Index demonstrated correlations between .59 and .83 for the Survey Interview Form and between .39 across age groups. The manual notes that in order to determine test-retest reliability stability a sample of 414 respondents from the standardization sample completed two forms of the Vineland-II on separate occasions (between 13 and 34 days from the first administration). Average correlations were found to range between .76 and .92 across domains (with the exception of the Maladaptive Behavior Subscales and Index), subdomains, and ages. The Maladaptive Behavior Subscales and Index have test-retest correlations ranging from .74 to .98.

The sources of validity evidence listed in the VABS-II manual come from test content and structure, clinical groups that use it and comparison with other measures. Regarding the test content, the VABS-II was designed to measure 4 major aspects of adaptive functioning: Communication, Daily Living Skills, Socialization and Motor Skills. Each of the domains has subdomains each with target behaviors which are deemed important to adaptive functioning. The content of the Vineland-II is supported from several important sources including American Association on Cognitively delayed (2002), American Psychological Association (1996), and the National Academy of Sciences, as well as from the previous version of the Vineland. As to the clinical groups, it would be expected that certain groups would present with distinctive score profiles. The clinical groups included: Cognitively delayed, Autism, Attention-Deficit/Hyperactivity Disorder, Emotional/Behavioural Disturbance, Learning Disability and Visual and Hearing Impairments. It was demonstrated that generally those with cognitive delays have a mean adaptive behavior composite score two standard deviations below the mean of the nonclinical group. An adaptive measure score of this nature is required for diagnosis as listed in the DSM and by the American Association for Cognitively delayed. For those with autism, again it was found that they generally have a mean score two standard deviations below the mean of the nonclinical sample. The VABS-II score profiles also were able to differentiate severity among individuals with cognitively delayed and autism. Finally, in relation to comparison with other measures, the VABS-II scores were also compared to scores on the Adaptive Behavior Assessment System-Second Edition for 197 individuals. The overall Adaptive Behavior Composite on the Vineland-II and the General Adaptive Composite from the Adaptive Behavior Assessment System-Second Edition correlated at .70. Using a sample of 236 children and adolescents, the Vineland-II scores were also compared to those produced by the Behavior Assessment System for Children, Second Edition parent rating form. It should be noted that the Vineland-II measures mostly adaptive behavior while the Behavior Assessment System for Children, Second Edition measures predominately maladaptive behavior with a section devoted to adaptive skills. The most similar subscales were correlated and results indicated a range of .34 to .74 across the age range. Maladaptive scales on the Vineland correlated with the Behavior Symptoms Index on the BASC-2 at .80 for the Parent Rating Form - Child and .69 the Parent Rating Form - Adolescent.

5.9 Interviews with Teachers

Interviews seek to describe the meanings of central issues from the interviewees' perspective and, unlike an ordinary, everyday conversation, have a specific purpose and the questions asked by the interviewer serve this purpose (Kvale, 1996; Dyer, 1995). Interviews can be used to evaluate or assess an individual in some respect; serve as a therapeutic tool (for example a psychiatric interview); assess the employability of a person; to gather research data and test hypotheses (Cohen, Manion and Morrison, 2011). Before someone conducts an interview it is crucial to set the aim and decide on the desired group of participants for the interview, so as to then be able to choose the most suitable interview type. LeCompte and Preissle (1993) identify six types of interview: standardised; in-depth; ethnographic; elite; life history; focus groups. Bogdan and Biklen (1992) add to this the semi-structured and group interviews. Furthermore, Lincoln and Guba (1985) add the structured interviews and Oppenheim (2000) adds to this the exploratory interviews.

For the purposes of this particular study, the type of interview that was used was the semi-structured interview (Bogdan and Biklen, 1992). A semi-structured interview has pre-determined questions, but the order or the question wording can be modified according to the interviewer's perception of what is more appropriate in the particular situation (Robson, 2002). Moreover, they are flexible and allow the discussion and clarification of more complex issues. Additionally, it is the best way to get participants' views and explore in-depth elements that cannot easily be obtained by observation or questionnaires. On the other hand, the researcher has to bear in mind that they can be time-consuming and require careful preparation in terms of the content of the questions, arrangements to visit and length. Therefore, effort has been made to conduct the interviews at the teachers' convenience, include information that cannot cause the participants any distress and keep the interview in an average limit of thirty minutes, so as to be manageable in the transcription process (Robson, 2002).

The interviews lasted 45 minutes each and were conducted in the staff room of the school. During the interview only the researcher and individual teacher were present. The questions focused on children's balance, body awareness and planning skills after the use of the software across the different school environments. Furthermore, video-recordings of the children working with the software were presented to the teachers so as to comment on the children's skills within this environment. As it would be impossible for them to watch three hours of video recordings, the researcher provided the videos before the interview so that they could watch them in advance. These type of questions were asked by the researcher in order to see whether the quantitative data that was analysed for the intervention group matched what the teachers said. Additionally, there were questions about Pictogram Room in general that the researcher left open to the teachers to answer without giving any direction (See Appendix 6 for the interview questions). This was because she wanted their opinion on the overall development of the study, what they thought about each child and the work with the software. This practice, would help the researcher answer the fourth research question of the study and also see whether any new information would emerge.

5.9.1 Piloting of the interviews

The interviews were piloted with two post-graduate students, one doing a PhD in Education working with school-aged children and their teachers, and also a Masters' student specialising on inclusive education of children with autism in mainstream classrooms. The piloting of the interview took place at the end of the data collection for the intervention group, one week before the interview session with the two teachers. The conclusions from the piloting related to changing the wording of some questions, as they were not simple enough and also adding clarification and visual supports to several questions (e.g. figures and graphs on which staff had to comment). Also, they suggested providing the teachers with the definitions of sensory-motor skills (e.g. body awareness items from the BBAP checklist).

5.10 Validity

Validity refers to the degree to which 'a method, a test or a research tool actually measures what it is supposed to measure' (Wellington, 2000, p. 201). Cohen et al. (2011) and Robson (2002) suggest piloting the research tools to enhance their validity, which was done for one of the two assessments the researcher developed due to time constraints. Moreover, employing standardised measures or instruments which are known to have good validity can add to a study's overall validity and this is the main reason that the research used them. External, internal and ecological validity are important to consider when designing a research study. Both external and internal validity are two validity types that can be problematic in naturalistic studies (Yin, 2003a). External validity relates to the extent to which the findings of a study can be generalised (Cohen et al., 2011), whilst internal validity refers to the potential of a causal relationship between two or more variables (Bryman, 2008). The researcher followed Burn's (2000) advice, providing a full description of the unit of analysis so that the readers can then decide whether the findings apply to their case or not. In addition to that, during year two a control group was recruited so if the changes in the intervention group were still significant when compared to the control group, then it could be assumed that there is a causal relationship between the dependent and independent variable. Ecological validity considers whether 'social scientific findings are applicable to people's every day, natural social settings' (Bryman, 2008, p. 33). Therefore, if a study is conducted in a school setting without changes to the curriculum and the daily timetable of the class, its ecological validity is high and this is one of the main reasons the researcher conducted the study at a school setting.

5.11 Reliability

Reliability is a concept closely linked to validity. It is often difficult to achieve this in real world research (Wellington, 2000). The term can have different meanings in quantitative and qualitative research (Cohen et al., 2011). In quantitative studies, reliability is used to ascertain whether if the same methods were used with a similar sample, the results would be the same. In the case of qualitative research, reliability refers to the accuracy between what the researcher records and what is actually happening. The term dependability instead of reliability is often used in qualitative studies (Robson, 2002). One of the methods the researcher used to ensure reliability was inter-rater reliability. This is a method that involves coding of the data by different raters and gives a score on the consensus that there is on their ratings (Cohen et al., 2011). More information of how it was used in this study is given below.

5.11.1 Reliability of BBAP

Inter-rater reliability was checked by two Special Education Needs (SEN) teachers who both had a Master of Education qualification. One of them had specialised in children with autism and the other one in special education needs more broadly. They were blind to the aims of the research study and to the order in which the videos were taken, in the sense that they did not know if they were taken at the beginning or at the end of the study. The researcher provided the BBAP along with the definitions of each item and trained them on different video samples until an 80% agreement was achieved. Then each of the teachers independently coded 30% of the total video samples (i.e. 12 out of 40 videos). This percentage exceeds the 20% minimum of sessions across conditions that has been recommended by Reichow et al. (2008). An 85% inter-observer reliability agreement (range from 81% to 89%) was reached for the Balance and Motion score. An 82% inter-observer reliability agreement (range from 70% to 82%) was reached for the Body Awareness and an 82% (range from 80% to 86%) was reached for the Planning and Ideas. These percentages exceed the minimum 80% Reichow et al. (2008) recommend.

5.11.2 Reliability of SPA

The researcher performed inter-reliability check for the SPA. Inter-rater reliability was checked in a similar manner by the same two Special Education Needs (SEN) teachers who did the reliability check for the BBAP. The researcher provided the SPA along with the definitions of each of the types of social play and trained them on different video samples until an 80% agreement was achieved. Then each of the teachers independently coded 30% of the total video samples (i.e. nine out of 30 videos). This percentage exceeds the 20% minimum of sessions across conditions that has been recommended by Reichow et al. (2008). For the frequencies an 82% inter-observer agreement (range from 79% to 84%) was reached. This percentage exceeds the minimum of 80% percent that is recommended (Reichow et al., 2008). However, for the duration, a 78% inter-observer agreement was reached (range from 74% to 79%). This might be because the two raters did not use ELAN for the coding but they hand coded the videos which increased the possibility for human error (Wittenburg et al., 2006).

5.12 Overview of the data analysis

As mentioned previously, for the purposes of this phase of the study, both quantitative and qualitative data were collected. For the analysis of the quantitative data gathered through checklists developed by the researcher and a standardised assessment, both t-test and effect size (Cohen, 1988; Dancey and Reidy, 2002) were used.

An Excel spreadsheet was created with the t-test and the effect size formula. For the analysis of the qualitative data from the teachers' interviews a thematic analysis approach was followed. For the management and coding of the data the NVivo software (QSR International Pty Ltd, 2012) was used. Also, the data is presented at a group level and at an individual level see whether there are extreme differences in sensory-motor skills between the participants and thus to a certain degree check the heterogeneity of the group.

5.12.1 T-tests and Effect size

The t-test is one of a number of hypothesis tests and it assesses whether the means of two groups are statistically different from each other. The unpaired t-test is used to compare to population means that they are different. On the other hand, the paired t-test is used to compare two population means where there are two samples in which observations in one sample can be paired with observations in the other sample. For this data a paired t-test was carried out as the before and after observations and assessments were carried out with the same participants. The t-test was chosen to test the effectiveness of the intervention and see the significance of the potential difference before and after. Some researchers have cautioned against using the t-test when the sample size is extremely small (i.e. <=5), as the result will imply low statistical power (e.g. Pashler and Harris, 2012). However, others have suggested that using the t-test is feasible in such a case as long as either there is normal distribution of the sample or the effect size is very large (Fritz, Morris and Richler, 2012; de Winter, 2013). In the case that the sample size is very small, as in this study, using a t-test might pose threats to validity, since it is very hard to generalise the findings to the greater population. As noted previously, one of the ways that acceptable statistical power with very small sample sizes can be reached, is if the effect size is very large (i.e. >=0.8) (de Winter, 2013). Therefore, the researcher calculated effect sizes as well as t-tests.

A t-test's effect size indicates whether the difference between the pre- and post-intervention sample means is large enough to have practical meaning (Cohen, 1988). This is independent of whether or not it is statistically significant. The effect size is the main finding of a quantitative study. While a *p* value can inform the reader whether an effect exists, the *p* value will not reveal the size of the effect. In reporting and interpreting studies, both the substantive significance (effect size) and statistical significance (*p* value) are essential results to be reported. That is because if we take for example very large samples we are very likely to find great statistical significance but the effect might be small and therefore the differences meaningless. Also, when there are small sample sizes we might have no or little statistical significance but the effect might be large (Carson, 2012).

The most common type of effect size for the t-test is Cohen's d (Carson, 2012). Cohen's d is used to show the size of the difference between group means in terms of standard deviations (Cohen, 1988) and provides the clinical or practical significance of the difference (Dancey and Reidy, 2002). It can be measured by the standardised difference between two means, or mean (group 1) – mean (group 2) / standard deviation. Cohen's term *d* is an example of this type of effect size index. Cohen classified effect sizes as *small* (d = 0.2), *medium* (d = 0.5), and *large* ($d \geq$ 0.8) (Carson, 2012). According to Cohen, a medium effect of .5 is visible to the naked eye of a careful observer. A small effect of .2 is noticeably smaller than medium but not so small as to be trivial. A large effect of .8 is the same distance above the medium as small is below it (Cohen, 1988). The importance of effect size calculations is highlighted by the APA, which recommends these for every published work (Field, 2005). More and more international journals have either added effect size to the statistical significance calculations or replaced them with effect size (Cohen et al., 2011). If the effect size is 0.8 or more, researchers can be confident that they have detected a real effect. If it is less than this, they may need to replicate the study, with more participants to increase the power (Field, 2005).

5.12.2 Thematic analysis

As with all qualitative data, analysis involves processes such as coding, categorising and making sense of the essential meanings of the phenomenon. In this study, a thematic data analysis was adopted (Edwards and Titchen, 2003). This allowed for systematic identification of the teachers' interpretations, views and observations of the children participated in the study, which then were incorporated to the quantitative data in order to provide a better understanding and inform further actions. The stages of the analysis involved familiarisation with the data , generating initial codes, reviewing themes among these codes, reviewing themes, defining and naming themes, and producing the final report (Braun and Clark, 2006). For the purposes of this study, the researcher used a 'hybrid' of thematic analysis, which involved both predetermined themes but also themes that emerged from the data collection (Braun and Clark, 2006). This approach was followed because the predetermined themes would give the researcher information about children's sensory motor skills and she would be able to compare those to the results from the quantitative measures. On the other hand, the emerging themes would help her with understanding teachers' views on the intervention and the study process overall and would help her to further inform her study. For the organisation, coding and modeling of the data from teachers' interviews, qualitative data management software, called NVivo (QSR International Pty Ltd, 2012) was used.

During the first stage the researcher transcribed the interviews and then spent time reading through the text to make sense of the data and become familiar with the teachers' perceptions. When the text was prepared she listened to the audio recordings to give a better sense to the written text. Emerging topics and thoughts were documented in NVivo using memos. During stage two, the researcher tried to understand the teachers' ideas that were expressed in their own words so as to capture the precise detail. These ideas were related to the research questions and are linked to the success or otherwise of the intervention. They also referred to any recommendations and limitations. To capture these ideas the researcher assigned codes to different thematic categories. The codes were both predetermined and not predetermined reflecting the pragmatist epistemological approach of the study. These codes are called nodes in NVivo. For example, when a teacher was discussing in which environment she noticed the greatest improvement the code/node 'environment effect' was used. The coding process, also involves what is called data reduction, in which codes are grouped together for better management and understanding. For example, the parts of the interview transcripts that were assigned the code 'environment effect' were then grouped into the different environments the researcher was investigating (for example Playground or PE). The next stage involved the process of searching for themes. Searching for themes and considering what fit and what did not fit within themes, enabled the researcher to begin the analysis of the codes. In this phase it was important to begin by examining how codes combined to form themes in the data and how relationships were formed between codes and themes, and between different levels of existing themes. For this process the researcher used the modelling function in NVivo which provides a visual representation of how codes are grouped to lead to a theme. For example, when the codes were grouped into the different environments the theme that was used was 'generalisation of children's sensory-motor skills across different environments'. After this, the researcher reviewed the themes that were used so as to reassure their validity and how they connected to the data. The final two stages were to finalise the definition and naming of the themes and create links with the literature, by reporting and interpreting the data. The stage of interpretation was mainly used for the Discussion (Chapter 7) of the study.

The next section discusses the ethical issues arising which are particularly important when working with vulnerable children and young people. Additionally, ethical considerations are of great significance when the researcher is using a video camera in the classrooms (Heath et al., 2010).

5.13 Ethical Considerations

Ethical considerations are of great importance when conducting research. They are defined as 'rules of conduct' (Robson, 2002, p. 65) and they form a set of principles distinguishing socially acceptable behaviours from socially unacceptable. Ethical issues usually come from the kind of the subject social scientists investigate and thus the methods they use to get valid and reliable data (Cohen, et al. 2011). In any kind of research the main issue is to ensure the participants' well-being and the protection of their rights. Hence, the researcher so as to be sure that has taken everything into account, requested an ethical approval from the University of Birmingham Ethical Review Committee, regarding the elements of the study. A favourable decision was given on the 17/10/2012 (Application for Ethical Review ERN_12-1042; Appendix 7).

The ethical issues for every kind of research should be the protection of human rights. These are mainly achieved by using informed consents for the individuals participating in the study (Israel and Hay, 2006). It was crucial to obtain consent forms from teaching staff and the children's parents. Although it would have been ideal to also obtain consent from the children, their young age and their communication difficulties related to autism rendered them unable to give consent, therefore the parents decided whether they wanted them to participate. Two types of consent forms were developed, one for the parents and one for the teachers and one assent form for the children (a copy of each can be found in the Appendices). These forms provide the participants with some information about the researcher, explain in general the study focus and make clear to them that they have the right to withdraw at any point of the study if they wish. The staff's consent forms were distributed and collected in person by the researcher. The parents' forms were sent home via home-school books. Also, the control group that was recruited for the purposes of the study, was a wait-list control group, which meant that the children consisting this group would receive the intervention after the end of the study.

Ensuring participants' confidentiality (Robson, 2002; Lankshear and Knobel, 2004), especially where the cases might be easily identified, is another very important ethical issue. For this reason, labels according to the participants status are given (e.g. Child 1, Child 2, etc.) and used throughout the whole research (collecting and presenting data in all stages). A list with the participants' names and their labels is kept at the researcher's home. This list will be kept for 10 years after the completion of the study as the University of Birmingham Ethical Review Committee suggests.

5.14 Summary

This chapter presented the sequence of the study implementation in order to give an overview of what was involved in the study. The researcher then described Pictogram Room and the activities that she used for the purposes of the study. It was important to involve the teachers in this process as they are the ones who know the children best and they would be able to identify the activities that they would be best to work with for the development of sensory-motor skills. Then the implementation of the intervention was presented and the fidelity of implementation the researcher followed. Furthermore, the different methods of data collection were discussed and how they helped to answer the study's research questions. Research constructs such as validity and reliability of the study were also explained. The researcher also provided a detailed description of how she analysed the data. The chapter concluded by reporting the ethical considerations encountered. The next Chapter presents the findings of the study.

CHAPTER 6

FINDINGS

6.1 Introduction

As highlighted in the previous chapter, the overarching research aim was to i) implement an intervention, which used a game-like free body movement environment, and ii) measure its effects on children's sensory-motor development. A sequential mixed methods approach was followed, substantively using quantitative methods, whilst also drawing on qualitative methods of data collection. The findings of the study regarding the impact of the intervention on children's sensory-motor skills overall are presented in this chapter. Initially, they are presented for the intervention group alone, and then with the intervention and the control group. Furthermore, findings from the intervention group are reported across all environments (i.e. Software, PE, Classroom, Playground and Home), followed by the comparison between the intervention and the control groups across all environments, except the Software. Results on the sensory-motor subdomains (i.e. Balance and Motion, Body Awareness and Planning and Ideas), are also reported to see which one developed to a greater extent, first for the intervention group alone, and then for both groups. Moreover, for all the above, findings from both BBAP and SPM are presented. The findings from the teacher interviews are then presented, as they help form a more holistic view of the first three research questions on the intervention group only. They also help answer the fourth research question whilst indicating how the interviews led to the emergence of a new research question. Finally, findings are reported on the last research question, which emerged from the teachers' interviews. This focuses on social play and adaptive behaviours, and the differences between the intervention and the control group in those skills. Before moving onto presenting the findings, a brief note of how the data was analysed is outlined. For the analysis of the data obtained from BBAP, SPM, SPA and VABS-II, t-tests were carried out, in addition to calculation of Cohen's d effect size for the practical significance. For the analysis of teachers' interviews, a thematic analysis approach was followed.

This findings of study, are presented in such a way that answers the study's research questions:

<u>The main research questions of the study were:</u>

1. Can Pictogram Room enhance the sensory-motor skills of children with autism?

2. In which environment/s do the sensory-motor skills of the children with autism develop to a greater extent (i.e. Software, Classroom, Home, Physical Education, Playground)? Were they generalised outside the Software environment?

3. Which sensory-motor sub-domain improved more (i.e. Balance and Motion, Body Awareness and Planning and Ideas)?

4. Are the findings of the first three research questions different when just analysing the data from an intervention group compared to when comparing the intervention to a control group?

5. What are the ways that Pictogram Room can be used in a school setting?

Post hoc research question from the teachers' interviews:

6. Were there any differences in social play and adaptive skills between the intervention and the control group?

6.2 Overall sensory-motor development for the intervention group

6.2.1 Overall sensory-motor score from BBAP

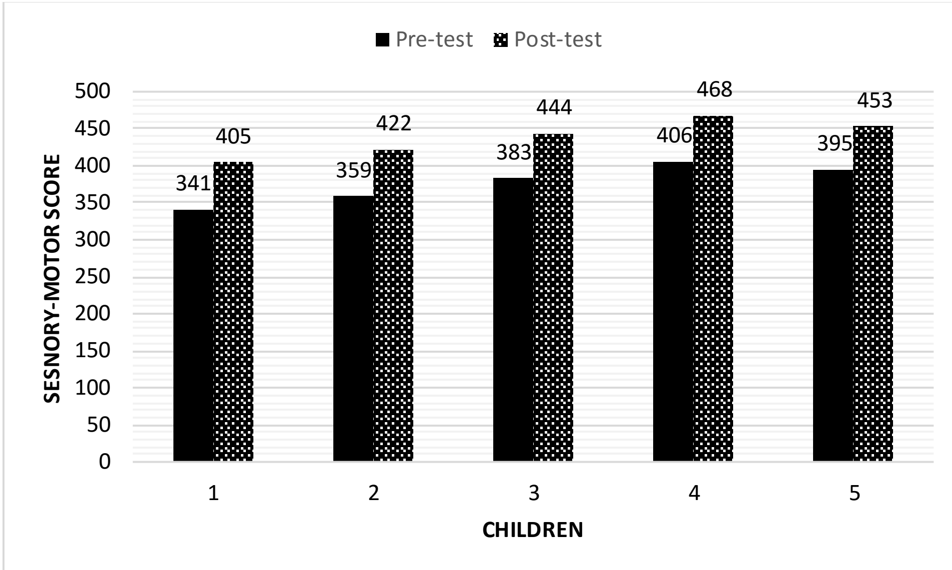
Children were filmed in four environments (i.e. software, classroom, PE and playground) and the data was obtained using the BBAP checklist. Although the same checklist was used for the home environment, it was not possible to have video recordings from this environment. For the home environment, parents filled out the BBAP, whilst the researcher filled in the checklist for the school environments. The data was obtained from three-hour observations, pre and post-intervention, across each environment. For the Software environment, the three hours refer to the first and last cycle of six sessions. The effectiveness of the intervention is shown in Table 5 and the data for each child is presented in Figure 3.

Table 5: Effectiveness of the intervention overall for sensory-motor development across 5 environments

Pre-intervention Mean:	376.8
Post-intervention Mean:	438.4
Pre-intervention Standard Deviation:	26.55
Post-intervention Standard Deviation:	25.02
t(4)=59.83 p=0.0001 (statistically significant)	
Cohen's d: 2.3 (Large effect size)	

A paired t-test was conducted to compare children's sensory-motor skills before and after the intervention. There was a significant difference in scores for sensory-motor performance before the intervention (M=376.8, SD=26.5) and post-intervention (M=438.4, SD=25); t(4)=59.83, p=0.0001. Additionally, to communicate the practical significance of the results, Cohen's d effect size was also calculated. Cohen's d was 2.3, which exceeds by far the 0.8 cut-off score for a large effect size. This means that the sensory-motor skills of the children increased significantly after the intervention.

Figure 3 Overall score for sensory-motor development across 5 environments



All children increased their score on sensory-motor performance after the introduction of the intervention (see Figure 3). The difference in the children's score ranged from 58 to 64, with Child 1 showing the greatest improvement and Child 5 the least. However, the differences in children's scores are very similar, suggesting a certain homogeneity of the group.

6.2.2 Overall sensory-motor score from SPM

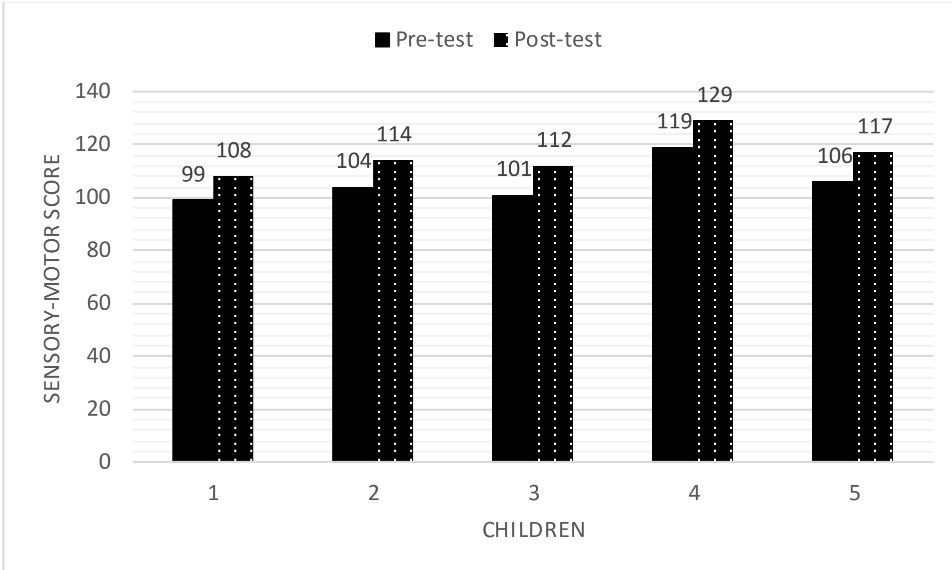
Children's parents, teachers and teaching assistants completed two assessment forms. Parents completed the SPM-Home form and teachers completed the SPM-Main Classroom form. As seen from the forms, these assessments provided information for two environments instead of five. SPM is a standardised measure with specific forms that do not correspond to the rest of the environments. The effectiveness of the intervention as measure by the SPM forms is shown in Table 6 and the data for each child is presented in Figure 4.

Table 6: Overall Sensory-motor development across 2 environments

Pre-test Mean:	105.8
Post-test Mean:	116
Pre-test Standard Deviation:	7.85
Post-test Standard Deviation:	7.96
t(4)=27.26 p=0.0001 (statistically significant) **Cohen's d:** 1.2 (Large effect size)	

A paired t-test was conducted to compare children's sensory-motor skills before and after the intervention. There was a significant difference in scores for sensory-motor performance before the intervention (M=105.8, SD=7.85) and post-intervention (M=116, SD=7.96); t(4)= 27.26 , p=0.0001. Cohen's d was 1.2, which exceeds by far the 0.8 cut-off score for a large effect size. This means that the sensory-motor skills of the children increased significantly after the intervention. Although there was no data from the other environments, the effect of the intervention at Home and in the Classroom all together was significant.

Figure 4 Overall Sensory-motor development across 2 environments



All children increased their score on sensory-motor performance after the introduction of the intervention (see Figure 4). The difference in the children's score ranged from 9 to 11, with Child 3 and Child 5 having the greatest and Child 1 the least. Again, the differences in children's scores are very similar, again suggesting a certain homogeneity of the group.

6.3 Overall sensory-motor development between the intervention and the control group

6.3.1 Sensory-motor score from BBAP

Children in both the intervention and control group were filmed in three environments (i.e. Classroom, PE and Playground) and the data was obtained using the BBAP checklist over a three-hour observation pre and post-test across each environment. Although the same checklist was used for the home environment, it was not possible to have video recordings and parents filled the form in, unlike the others that were completed by the researcher. The effectiveness of the intervention is shown in Table 7.

Table 7: Overall sensory-motor development between the intervention and the control group from BBAP

	Group						
	Intervention (n=5)		`Control (n=5)				
	Mean	**SD**	**Mean**	**SD**	**t**	**p**	**Cohen's d**
Before-intervention	287.8	18.74	286.8	13.26	0.33	0.75	0.06
After-intervention	319	20.29	295	12.17	5.38	0.0058	1.4

Df=4

A paired t-test was conducted to compare children's sensory-motor skills before and after the intervention. There was a significant difference in scores for sensory-motor performance before the intervention (Intervention group: M=287.8, SD=18.74; Control group: M=286.8, SD=13.26; t(4)=0.33, p=0.75) and post-intervention (Intervention group: M=319, SD=20.29; Control group: M=295, SD=12.17; t(4)=5.38, p=0.0058) between the two groups. Cohen's d after the intervention was 1.4, which exceeds by far the 0.8 cut-off score for a large effect size. This means that the sensory-motor skills of the children in the intervention group increased significantly more, compared to the children in the control group.

6.3.2 Overall sensory-motor score from SPM

Children's parents and teachers completed two different assessment forms for each child in both groups. Parents completed the SPM-Home Form and teachers the SPM-Main Classroom Forms. The results of these assessments, for the overall difference in sensory-motor skills between the two groups, is presented in Table 8.

Table 8: Overall sensory-motor development between the intervention and the control group from SPM

	Group						
	Intervention (n=5)		**`Control (n=5)**				
	Mean	**SD**	**Mean**	**SD**	**t**	**P**	**Cohen's d**
Before-intervention	105.8	7.85	103.6	6.18	1.01	0.36	0.3
After-intervention	116	7.96	108.4	6.02	3.31	0.029	1.07

Df=4

A paired t-test was conducted to compare children's sensory-motor skills before and after the intervention. There was a significant difference in scores for sensory-motor performance before the intervention (Intervention group: M=105.8, SD=7.85; Control group: M=103.6, SD=6.18; t(4)=1.01, p=0.36) and post-intervention (Intervention group: M=116, SD=7.96; Control group: M=108.4, SD=6.02; t(4)=3.31, p=0.029) between the two groups. Cohen's d after the intervention was 1.07, which exceeds by far the 0.8 cut-off score for a large effect size. This means that the sensory-motor skills of the children in the intervention group increased significantly more, compared to the children in the control group. These results reflect those from the BBAP checklist.

6.4 Effect of different environments on sensory-motor development for the intervention group

6.4.1 Results on the effect of different environments on sensory-motor development from BBAP

The children were video recorded in four environments (i.e. software, PE, classroom, playground) and the score on their sensory-motor skills was obtained through BBAP. For the home environment, as mentioned previously, there were no video recordings as the researcher could not have access to the children's homes, and instead the children's parents completed the BBAP. The environments varied across a number of pairs of variables (i.e. structured vs unstructured, must do versus fun, adult-directed versus child-directed, familiar vs unfamiliar, preferred versus non-preferred, easy vs difficult, busy vs calm), as recommended by the authors of the SCERTS model, to gain representative data (Prizant et al., 2006).

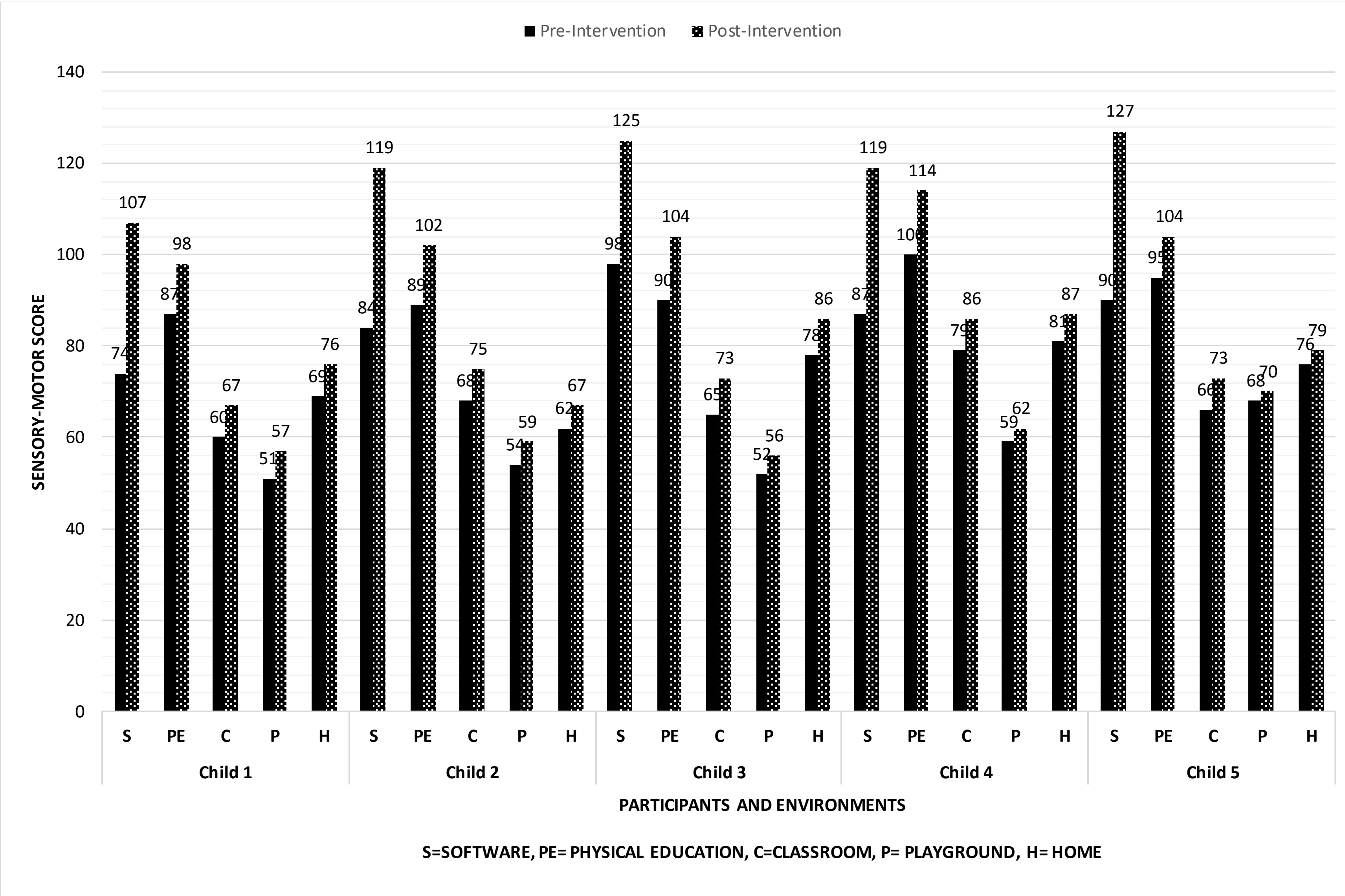
Table 9: Effect of different environments on sensory-motor development from BBAP

Environment	Cohen's d Effect Size	t-test	Pre-Intervention Mean and SD	Post-Intervention Mean and SD
Software	**3.9** (large)	**p=0.0001** t(4)=19.46	86.6 and 8.76	119.4 and 7.79
PE	**2.1** (large)	**p=0.0002** t(4)=12.58	92.2 and 5.26	104.4 and 5.89
Classroom	**1** (large)	**p=0.0001** t(4)=36	67.6 and 7.02	74.8 and 6.94
Playground	**0.63** (medium)	**p=0.0048** t(4)=5.65	56.8 and 6.97	60.8 and 5.63
Home	**0.73** (medium to large)	**p=0.0025** t(4)=6.74	73.2 and 7.66	79 and 8.15

A paired t-test was conducted to compare children's sensory-motor skills before and after the intervention in five environments. In all environments a statistically significant difference was noted (Software before intervention: M=86.6, SD=8.76, Software after intervention: M=119.4, SD=7.79; t(4)=19.46, p=0.0001, PE before intervention: M=92.2, SD=5.26, PE after intervention: M=104.4, SD=5.89; t(4)=12.58, p=0.0002, Classroom before intervention: M=67.6, SD=7.02, Classroom after intervention: M=74.8, SD=6.94); t(4)=36, p=0.0001, Playground before intervention: M=56.8, SD=6.97, Playground after intervention: M=60.8, SD=5.63); t(4)=5.65, p=0.0048, Home before intervention: M=73.2, SD=7.66, Home after intervention: M=79, SD=8.15); t(4)=6.74, p=0.0025).

Cohen's d effect size was also used. Interestingly, not all environments had the same practical significance. The Software, PE and Classroom environment had the most (i.e. 3.9=large effect size, 2.1=large effect size and 1=large effect size respectively). The home environment was close to showing a large effect size (0.73=medium to large effect size; close to the cut-off score of 0.8). Finally, Playground had an effect size of 0.63=medium effect). Therefore, by calculating the effect size, it seems that the sensory-motor skills performance in each environment was ranked from higher effect to lower effect as follows: Software, PE, Classroom, Home and Playground.

Figure 5 Effect of different environments on sensory-motor development from BBAP



Across all environments, and from all children, there was improvement in sensory-motor skills. For the software environment, the difference in scores before and after the intervention ranged from 27 to 37, with Child 3 having the lower score and Child 5 the highest. In the PE, the difference in scores ranged from 9 to 14, with Child 5 having the lowest difference and Child 3 and Child 4 the greatest. For the Classroom environment, four children had the same score difference, for Child 1, Child 2, Child 4 and Child 5 the difference in their score being 7, and Child 3 had the greatest which was 8. In the Playground, the difference in scores ranged from 2 to 6, with Child 5 showing the least improvement and Child 1 the greatest. Finally, at Home, the score difference ranged from 3 to 7, again with Child 5 having the lowest and Child 1 the greatest (see Figure 5). The results on Child 5 seem to be in line with the overall score in sensory-motor development, as measured by the BBAP, but within the software environment Child 5 had the greatest improvement, compared to the other participants.

6.4.2 Results on the effect of different environments on sensory-motor development from SPM

Parents and teachers completed the two assessments of SPM for two environments (i.e. Classroom and Home).

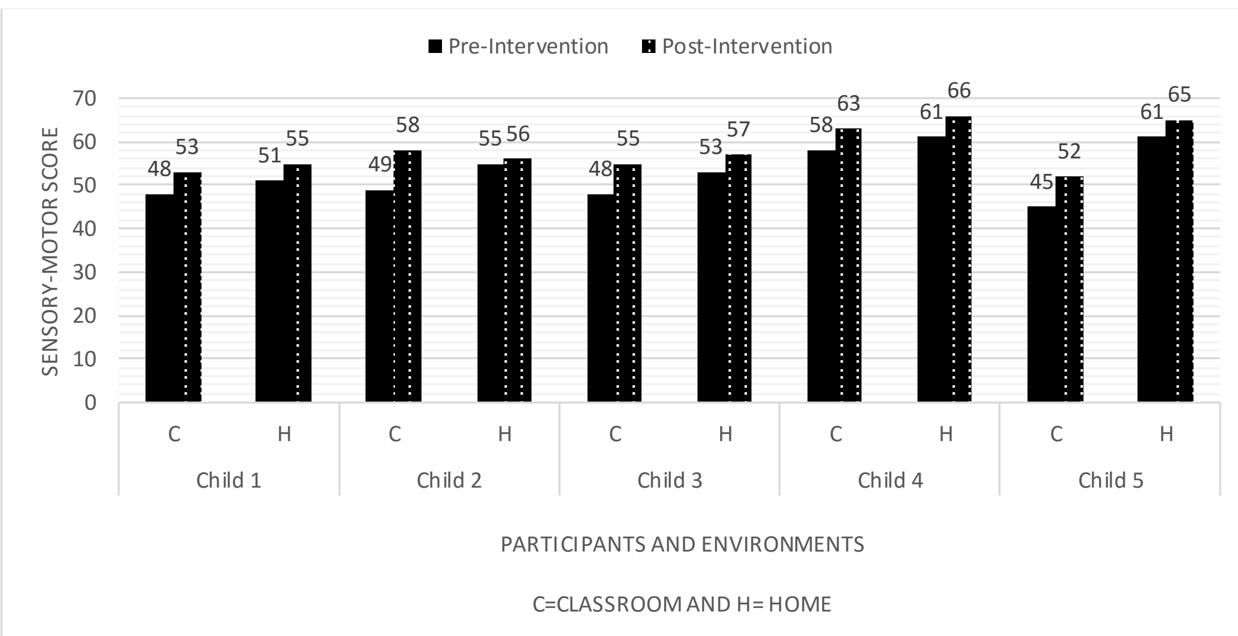
Table 10: Effect of different environments on sensory-motor development from SPM

Environment	Cohen's d Effect Size	t-test	Pre-Intervention Mean and SD	Post-Intervention Mean and SD
Classroom	**1.4** (large)	**p=0.0009** t(4)=8.81	49.6 and 4.92	56.2 and 4.43
Home	**0.72** (medium to large)	**p=0.0061** t(4)=5.30	56.2 and 4.60	59.8 and 5.26

The parents', teachers' and teaching assistants' ratings, reflected to a great extent the data obtained by coding the video recordings. A paired t-test was conducted to compare children's sensory-motor skills before and after the intervention in two environments. In both environments statistically significant difference was noted (Classroom before intervention: M=49.6, SD=4.92, Classroom after intervention: M=56.2, SD=4.43); t(4)=5.65, p=0.0048, Home before intervention: M=56.2, SD=4.60, Home after intervention: M=59.8, SD=5.26); t(4)=5.30, p=0.0061).

Here, as with the data from BBAP, all environments did not have the same practical significance. The Classroom environment had the most (i.e. 1.4=large effect size), similar to the data obtained with BBAP. The home environment was close to showing a large effect size (0.72=medium to large effect size; close to the cut-off score of 0.8), again similar to BBAP. Therefore, by calculating the effect size, it seems that the sensory-motor skills performance in each environment was ranked from higher effect to lower effect as follows: Classroom and Home.

Figure 6 Effect of different environments on sensory-motor development from SPM



Across both environments, and in all children, improvement in sensory-motor skills was also noticed when using the SPM. For Classroom environment, the difference in scores before and after the intervention ranged from 5 to 8, with Child 1 and Child 4 having the lowest difference and Child 2 the greatest. For the Home environment, the score difference ranged from 1 to 5, with Child 2 having the lowest and Child 4 the greatest (see Figure 6).

6.5 Effect of different environments on sensory-motor development between the intervention and the control group

6.5.1 Results on the effect of different environments on sensory-motor development from BBAP

The children were video recorded at three environments (i.e. PE, classroom, playground) and the score on their sensory-motor skills was obtained through BBAP. For the home environment, as mentioned previously, there were no video recordings as the researcher could not have access, and the children's parents completed the BBAP. The environments varied across a number of pairs of variables (i.e. structured vs unstructured, must do versus fun, adult-directed versus child-directed, familiar vs unfamiliar, preferred versus non-preferred, easy vs difficult, busy vs calm), as defined by the authors of the SCERTS model to gain representative data (Prizant et al., 2006).

Table 11: Effect of different environments on sensory-motor development between the intervention and the control group from BBAP

		Group						
		Intervention (n=5)		`Control (n=5)				
		Mean	**SD**	**Mean**	**SD**	**t**	**p**	**Cohen's d**
Before-intervention	**PE**	92.2	5.26	91.8	6.72	0.43	0.68	0.06
	Classroom	67.6	7.02	66.8	6.61	0.58	0.5870	0.2
	Playground	56.8	6.98	55.8	4.97	0.38	0.7189	0.1
	Home	73.2	7.66	72.4	2.07	0.23	0.8224	0.1
After-intervention	**PE**	104.4	5.9	93.2	6.98	7.6	0.001	1.7
	Classroom	74.8	6.94	69	6.75	2.4	0.06	0.8
	Playground	60.8	5.63	58.2	4.55	1.35	0.2457	0.5
	Home	79	8.15	74.6	2.3	1.25	0.2789	0.7

A paired t-test was conducted to compare children's sensory-motor skills before and after the intervention in four environments. In PE, a statistically significant difference between the intervention and the control group was noted after the intervention (PE intervention group: M=104.4, SD=5.9, PE control group: M=93.2, SD=6.98; t(4)=7.6, p=0.001). Also, Cohen's d effect size was 1.7, suggesting a very large practical significance. In the Classroom environment, the difference between the two groups was close to being significant (Classroom intervention group: M=74.8, SD=6.94, Classroom control group: M=69, SD=6.75; t(4)=2.4, p=0.06) and the practical significance was large (Cohen's d=0.8). The difference in sensory-motor skills development between the two groups in the Playground and Home environment was not significant (Playground intervention group: M=60.8, SD=5.63, Playground control group: M=58.2, SD=4.55; t(4)=1.35, p=0.24; Home intervention group: M=79, SD=8.15, Home control group: M=74.6, SD=2.3; t(4)=1.25, p=0.27). Although there was not statistical significance in these two environments, the practical significance was medium for the Playground environment (Cohen's d=0.5) and medium to large for the Home environment (Cohen's d=0.7).

6.5.2 Results on the effect of different environments on sensory-motor development from SPM

Parents and teachers completed two assessments forms from SPM for two environments (i.e. Classroom and Home). The results are presented in the table below.

Table 12: Effect of different environments on sensory-motor development between the intervention and the control group from the SPM

		Group						
		Intervention (n=5)		`Control (n=5)				
		Mean	**SD**	**Mean**	**SD**	**t**	**p**	**Cohen's d**
Before-intervention	**Classroom**	49.6	4.92	48.4	2.79	0.93	0.40	0.29
	Home	56.2	4.60	55.2	4.54	0.76	0.48	0.21
After-intervention	**Classroom**	56.2	4.43	50.6	3.43	3.50	0.02	1.4
	Home	59.8	5.26	57.8	4.49	1.69	0.16	0.4

The parents' and teachers' ratings, reflected to some extent the data obtained by the video. A paired t-test was conducted to compare children's sensory-motor skills, before and after the intervention, in the two environments that SPM measure sensory-motor skills. In the Classroom environment, the difference between the two groups after the intervention was statistically significant (Classroom intervention group: M=56.2, SD=4.43, Classroom control group: M=50.6, SD=3.43; t(4)=3.50, p=0.02) and the practical significance was large (Cohen's d=1.4). The difference in sensory-motor skills development between the two groups in the Home environment was not statistically significant (Home intervention group: M=59.8, SD=5.26, Home control group: M=57.8, SD=4.49; t(4)=1.69, p=0.16). Also, the practical significance was small to medium for the Home environment (Cohen's d=0.4).

6.6 Results on sensory-motor sub-domains across 5 environments for the intervention group

The researcher was looking into sensory-motor development through three different components. These were Balance and Motion, Body Awareness and Planning and Ideas (Pharham et al, 2007). The quantitative data for these sub-items was captured through BBAP and SPM and are presented below.

6.6.1 Results on sensory-motor subdomains across 5 environments as measured by the BBAP

Table 13: Results on sensory-motor subdomains across 5 environments as measured by the BBAP

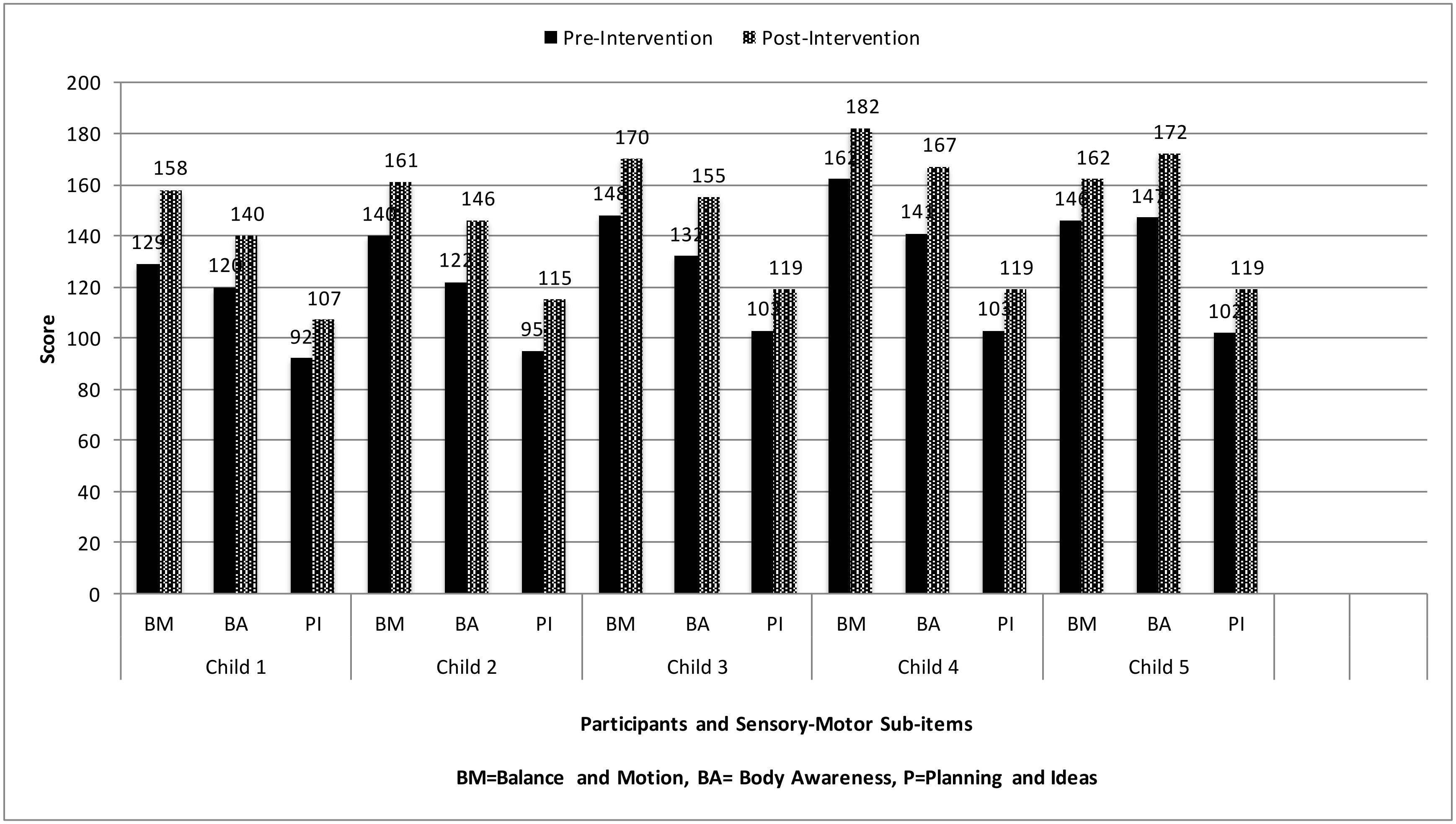
Sensory-Motor Sub-domain	Cohen's d Effect Size	t-test	Pre-Intervention Mean and SD	Post-Intervention Mean and SD
Balance and Motion	**1.9** (large)	**p=0.0005** t(4)=10.22	145 and 12.04	166.6 and 9.68

Body Awareness	**1.8** (large)	**p=0.0001** t(4)=22.92	132.4 and 11.71	156 and 13.54
Planning and Ideas	**3.2** (large)	**p=0.0001** t(4)=19.52	99 and 5.14	115.8 and 5.21

A paired t-test was conducted to compare children's sensory-motor sub skills, before and after the intervention, in five environments. All three items showed to be significantly improved (Balance and Motion before the intervention: M=145, SD=12.04, Balance and Motion after the intervention: M=166.6, SD=9.68; t(4)=10.22, p=0.0005, Body Awareness before the intervention: M=132.4, SD=11.71, Body Awareness after the intervention: M=156, SD=13.54; t(4)=22.92, p=0.0001, Planning and Ideas before the intervention: M=99, SD=5.14, Planning and Ideas after the intervention: M=115.8, SD=5.21; t(4)=19.52, p=0.0001.

Cohen's d effect size calculation showed that all sensory-motor items had great practical significance, with all of them having large effect (Balance and Motion Cohen's d=1.9, Body Awareness Cohen's d=1.8, Planning and Ideas Cohen's d=3.2). Therefore, by calculating the effect size, it seems that the sensory-motor sub skills performance in all environments was ranked from higher effect to lower effect as follows: Planning and Ideas, Balance and Motion, Body Awareness.

Figure 7 Results on sensory-motor subdomains across 5 environments as measured by the BBAP



All three sensory-motor subdomains showed improvement, as measured by the BBAP. Differences in the score, before and after the intervention for Balance and Motion, ranged from 16 to 29, with Child 1 showing the greatest improvement and Child 5 the least. In terms of Body Awareness skills, the difference in scores was between 20 and 26, with Child 1 showing the least improvement and Child 4 the greatest. Finally in Planning and Ideas, the difference in the score ranged from 15 to 20, with Child 1 again showing the least improvement and Child 2 the greatest (see Figure 7).

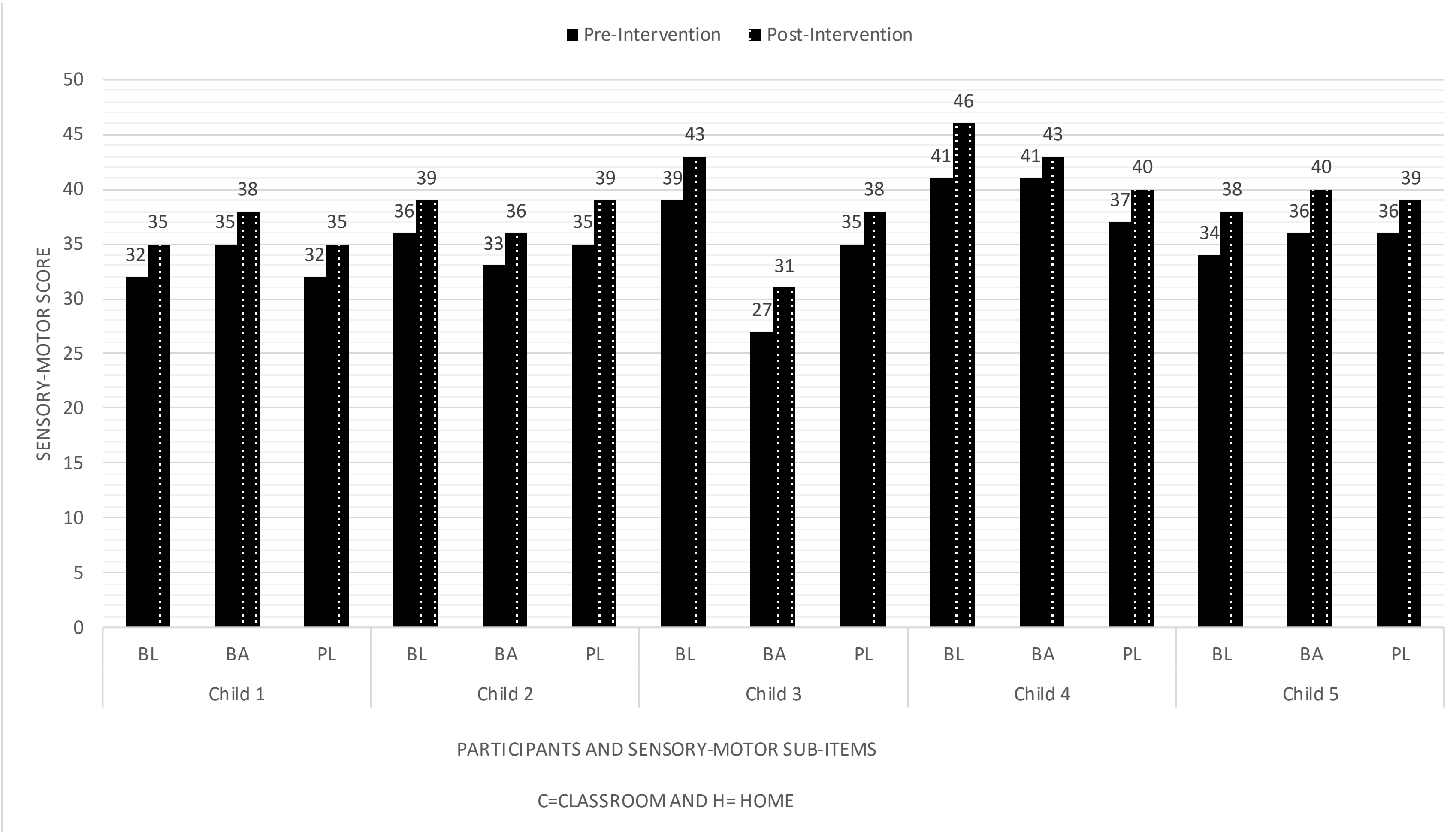
6.6.2 Results on sensory-motor subdomains across 2 environments as measured by the SPM

Table 14: Results on sensory-motor subdomains across 2 environments as measured by the SPM

Sensory-Motor Item	Cohen's d Effect Size	t-test	Pre-Intervention Mean and SD	Post-Intervention Mean and SD
Balance and Motion	**0.95** (large)	**p=0.0005** t(4)= 10.15	36.4 and 3.64	40.2 and 4.32
Body Awareness	**0.66** (medium)	**p=0.001** t(4)= 8.55	34.4 and 5.07	37.6 and 4.51
Planning and Ideas	**1.68** (large)	**p=0.0001** t(4)=16	35 and 1.87	38.2 and 1.92

A paired t-test was conducted to compare children's sensory-motor sub skills, before and after the intervention, in five environments. All three items showed to be significantly improved (Balance and Motion before the intervention: M=36.4, SD=3.64, Balance and Motion after the intervention: M=40.2, SD=4.32; t(4)= 10.15, p=0.0005, Body Awareness before the intervention: M=34.4, SD=5.07, Body Awareness after the intervention: M=37.6, SD=4.51; t(4)= 8.55, p=0.001, Planning and Ideas before the intervention: M=35, SD=1.87, Planning and Ideas after the intervention: M=38.2, SD=1.92; t(4)=16, p=0.0001. In addition, all sensory-motor items had great practical significance, with two of them having large effect; Balance and Motion Cohen's d=0.95, Planning and Ideas Cohen's d=1.68. Body Awareness had a medium effect size, with the Cohen's d being 0.66 in contrast to what it was found from BBAP. In this case, by calculating the effect size, it seems that the sensory-motor sub skills performance in both environments was ranked from higher effect to lower effect as follows: Planning and Ideas, Balance and Motion, Body Awareness. These results very closely reflect the results from the BBAP.

Figure 8 Results on sensory-motor subdomains across 5 environments as measured by the SPM



All three sensory-motor subdomains improved, as measured by the SPM as well. Differences in the score, before and after the intervention for Balance and Motion, ranged from 3 to 5, with Child 4 showing the greatest improvement and Child 1 and Child 2 the least. In terms of Body Awareness skills, the difference in scores was between 2 and 4, with Child 4 showing the least improvement and Child 3 and Child 5 the greatest. Finally in Planning and Ideas, the difference in the score ranged from 3 to 4 with Child 2 showing the greatest improvement and the rest of children presenting the same score difference, that of 3 (see Figure 8).

6.7 Results on sensory-motor sub-domains across different environments between the intervention and the control group

6.7.1 Results on sensory-motor sub-domains across 4 environments measured by the BBAP

Table 15: Results on sensory-motor sub-domains across different environments between the intervention and the control group from the BBAP

		Group						
		Intervention (n=5)		`Control (n=5)				
		Mean	**SD**	**Mean**	**SD**	**t**	**p**	**Cohen's d**
Before-intervention	**Balance and Motion**	113.6	7.7	113	6.6	0.26	0.8009	0.08
	Body Awareness	99	9.64	98.4	6.19	0.28	0.7904	0.07
	Planning and Ideas	75.2	2.77	75.4	2.51	0.13	0.8979	0.07
After-intervention	**Balance and Motion**	124.4	7.4	117	9.35	2.5	0.0657	0.8
	Body Awareness	108.4	9.07	100.4	5.77	2.8	0.0449	1
	Planning and Ideas	86.2	4.76	79	3.81	5.8	0.0044	1.6

A paired t-test was conducted to compare the two groups' sensory-motor sub skills, before and after the intervention, in four environments. Body Awareness and Planning and Ideas significantly improved (Body Awareness intervention group: M=108.4, SD=9.07; Body Awareness control group: M=100.4, SD=5.77; $t(4)= 2.8$, $p=0.04$; Planning and Ideas intervention group: M=86.2, SD=4.76; Planning and Ideas Intervention group: M=79, SD=3.81; $t(4)=5.8$, $p=0.0044$). The practical significance was also very large for both of these subdomains (Body Awareness Cohen's d=1; Planning and Ideas Cohen's d=1.6). The difference in Balance and Motion subdomain was close to significance between the two groups (Balance and Motion intervention group: M=124.4, SD=7.4; Balance and Motion control group: M=117, SD=9.35; $t(4)= 2.5$, $p=0.0657$). However, the practical significance was large, with the Cohen's d effect size being 0.8.

6.7.2 Results on sensory-motor subdomains across 2 environments as measured by the SPM

Table 16: Results on sensory-motor sub-domains across different environments between the intervention and the control group from the SPM

		Group						
		Intervention (n=5)		`Control (n=5)				
		Mean	SD	Mean	SD	t	p	Cohen's d
Before-intervention	Balance and Motion	36.4	3.64	35.6	3.43	0.64	0.55	0.22
	Body Awareness	34.4	5.07	33.8	3.11	0.43	0.68	0.14
	Planning and Ideas	35	1.87	34.2	2.94	0.57	0.59	0.32
After-intervention	Balance and Motion	40.2	4.32	37	3.31	2.13	0.09	0.83
	Body Awareness	37.6	4.50	35.6	2.88	2	0.11	0.52
	Planning and Ideas	38.2	1.92	35.8	3.03	1.86	0.13	0.94

A paired t-test was conducted to compare the two groups' sensory-motor sub skills, before and after the intervention, in five environments. None of the sensory-motor subdomains showed statistically significantly improvements for the intervention group, compared to the control after the intervention (Balance and Motion intervention group: M=40.2, SD=4.32; Balance and Motion control group: M=37, SD=3.31; t(4)= 2.13, p=0.09; Body Awareness intervention group: M=37.6, SD=4.50; Body Awareness control group: M=35.6, SD=2.88; t(4)= 2, p=0.11; Planning and Ideas intervention group: M=38.2, SD=1.92; Planning and Ideas control group: M=35.8, SD=3.03; t(4)=1.86, p=0.13. However, the practical significance for two of the three sensory-motor sub-domains was large, and medium for other. More specifically, Balance and Motion Cohen's d was 0.83, Planning and Ideas Cohen's d was 0.94 and Body awareness was 0.52. Unlike the data from video recordings, and in contrast to the results obtained through BBAP checklist, the difference in the Body Awareness subdomain was very low between the two groups, and no statistically significant differences were found.

6.8 Results from the teachers' interviews

As mentioned in the methodology, two out of three teachers participated in the interview and they were the teachers of the intervention group. Susan was the pseudonym for the teacher of Child 1 and Child 2, and Jean was the pseudonym for the teacher of Child 3, 4 and 5. However, these children were changing classrooms and participated together in other activities (e.g. PE so both teachers had knowledge of all the children). For this reason, both of them were asked about all five children. Also, it was important that both teachers where observing the children across all environments, as they could give feedback on PE and Playground where no assessments from teachers were used. Additionally, as mentioned in the previous chapter, the approach followed for the analysis of the interview data was a 'hybrid' of thematic analysis. This was because there was a mixture of predetermined and emergent themes. This part of the reporting of results will, therefore, be split into two sections; the first one will report on the results from the predetermined themes, which were: 1. Overall sensory-motor development, 2. Effects of different environments and 3. Sensory-motor sub-domain development. The next section will focus on the themes that emerged from the interview data.

6.8.1 Overall sensory-motor development from teachers' interviews

This section presents teachers' views on children's sensory-motor development. Susan thought that all children benefited, but mostly Child 1 and Child 4. She specifically mentioned:

> *'I think Child 1 is more confident now. He moves in the environment knowing where to place his body. Before he would bump in the people and the objects around him. He is more aware of where he is and his sensory-motor performance is much better'.*

She added:

> *' Child 4?! Oh he is something else! I can't believe he is the same child. He would find it hard to coordinate his hands, his legs… He is*

participating in more activities that require movement and his overall sensory-motor development is amazing!'

She said that she felt that the others also benefited, but it was not as clear as it was for Child 1 and Child 4.

Jean reported that she saw differences in the children's sensory-motor skills, especially in Child 1. That is in line with what Susan reported. However, she said that in Child 4 and 5 she thought that, although she saw some differences, they were not significant compared to their peers, who did not take part in the intervention. She specifically said:

> *'It was amazing to see how Child 1 improved and how his sensory-motor skills are better […]. […] All my students definitely benefited but I can't be so sure about Child 4 and 5. I mean… I see the other kids in the class and I think they have about the same improvement. I don't know like (another child's name not one of the participants) attends some OT classes so I don't know. It might be it.'*

Both teachers were unsure about some children, whether the intervention made a difference or whether the improvement just came in time. It was also hard for them to agree on the benefits in each individual child. For Susan, Child 4 was one of the children that improved more, but Jean did not see that. Finally, they both mentioned that Child 5 started occupational therapy towards the end of the study, but this might have influenced his performance overall.

6.8.2 Results on the effect of different environments on sensory-motor development from teachers' interviews

During the second part of the interview, teachers were asked about the environments where they noticed the greatest differences after the intervention, regarding children's sensory-motor skills. Both teachers reported the Software and the PE as the environments in which greatest improvement could be observed, with the greatest one in the Software. This reflected the findings from BBAP. Jean reported the Playground as the environment with the least improvement, which was consistent with the findings from the BBAP. However, Susan thought that in the classroom she found it hard to notice any obvious differences. This is opposed to the findings from the BBAP, that placed the Classroom just after PE, and also from the SPM, that Classroom had both a statistically significant difference and large effect size. Nonetheless, they both agreed that Playground was an environment that was hard to monitor changes.

Jean said:

> *'[In Playground] Children are less controlled. They do one thing and then the next moment they do something else. It's not as structured as the activities they do during PE'.*

When they were asked about each child individually, they both agreed that Child 5 had the greatest improvement in the Software environment. This was consistent with the findings from the quantitative data. They both mentioned that, in general terms, it was very hard to see changes outside the Software and the PE environment. Susan said:

> '[*In Software] Child 5 was amazing when working with Pictogram Room! I can't believe how engaged he was and performed all the activities much better. His whole body positioning and balance [while he was playing the 'body parts' activity] is unbelievably better!' [...] I think during PE and when playing with Pictogram Room it was clearly better for the kids. It was hard to say if this was the case outside those settings'*.

Teachers' doubts on generalisation of skills in other environments were reflected to some extent in the quantitative data. As although sensory-motor skills showed to be developed in the Software and the PE environments, difference in the Playground environment was not as significant. Unfortunately, the researcher could not have input on the Home environment, as parents did not participate in the interview process as part of this study. Also, the teachers were not present when children were using the Software, but the researcher showed them videos of each child at the beginning and at the end. This to some extent might be biased, as due to lack of teachers' time they could not watch three hours of video per child. However, the quantitative data also revealed the greatest improvement, something that teachers were not aware of at the time of the interview.

6.8.3 Results on sensory-motor sub-domains across all environments from teachers' interviews

For this part of the interview, the teachers were asked about which element/s of sensory-motor skills was/were developed the most. When the teachers completed the SPM, the questions were split in these items (i.e. Balance and Motion, Body Awareness, Planning and Ideas) so it made the interview clearer. Both teachers agreed that body awareness was developed to a greater extent. Jean specifically said:

> *'All children after starting using Pictogram room seemed less afraid to join physically demanding activities […]'*

Susan stated that:

> '*They seem more aware about others and it's like now they know where to be in space […]'.*

They also suggested that balance improved overall, but they did not think that the planning skills improved to a great extent. This is in contrast with the data from all the other assessments (i.e. BBAP, SPM). Although all three were shown to have significantly improved, 'Planning and Ideas' was shown to have improved even further. Furthermore, when they were asked about each individual child they both said that Child 5 had better body awareness. As seen from the two figures, the raw score of Child 5 pre and post-intervention had improved more, compared to other children, which is in line with the data presented in the figures. However, there was not a significant difference between the five children in the three sensory-motor domains.

6.8.4 Results from teachers interviews on further development

As part of the interview, teachers were asked to give their opinions and recommendations about the general study and how it could be improved. Their input was crucial for the study, as they helped to choose the activities in the software. Therefore, it was of great importance to see how things could be done differently, what worked well and what they would like to see next. Additionally, throughout the interview teachers were free to develop their ideas outside the questions, and were asked to have a more holistic view of the things that took place during the study. Unlike the first part of the interview results, in which the themes of sensory motor skills were predetermined, this part of the interview results reports on the themes that emerged after the coding of the data. Although the researcher used these predetermined themes to see whether the quantitative data were in line with the qualitative data, it was important to further inform her study by taking into account teachers' input that emerged from the interviews. The codes/nodes that emerged from coding teachers interviews' in NVivo were grouped into three main themes. The first was 'study implementation', the second one was 'other skills development', and the third one was 'potential of Pictogram Room to be used for collaboration between teachers and occupational therapists'. It was very important to obtain teachers' views on how the study could be improved or done differently, to inform further steps.

6.8.4.1 Study implementation

The interview results yielded important aspects regarding the design of the study. One significant point was that both teachers made reference to the use of Pictogram Room by two children, instead of an adult and a child. They both thought that this would be a great tool to promote peer communication and collaboration. Therefore, after the end of the data collection, they tried it with some students playing together and they were amazed by the results. Susan said:

> *'[…] I said: 'who wants to play?' I had the kids playing with their friends and it was great! They were showing each other what to do and they were interacting brilliantly!'*

Jean, in her interview, also pointed out that she would like to use it as a tool of inclusion. As the school that the study was conducted was a mainstream school with autism units, she addressed the potential of Pictogram Room as a way for the students with autism to to interact with their typically developing peers, and form friendships. She specifically said:

> *'It would be great if the kids from the mainstream classes acted as the instructor and tried to make the ASD students feel welcome. It's a great tool for inclusion, which is something we really want to happen in our school.'*

6.8.4.2 Other skills development

Throughout the interview the teachers were not only commenting on children's sensory-motor development, but also focused quite extensively on skills that were not the primary target of the research. Both teachers mentioned that after the intervention children started participating in more group activities and became more social. Additionally, they started interacting more with their peers and wanted to be part of a group to play during PE and recess. Jean said:

> '*Child 3 and Child 4 would never join in a group activity unless they were instructed to do so. […] Child 1 is seeking to play with others in recess and approaches his peers in a more appropriate way'.*

Susan mentioned that:

> *'Child 3 would always play by himself. He wanted to be with friends but did not know how. Sometimes he seemed to be afraid of some games and he wouldn't join in'.*

Susan also noted changes in children's adaptation to classroom rules. She indicated that:

> '*Child 2, Child 3 and Child 5 would not easily follow the classroom instructions. They would have a* difficult time adapting to the classroom's schedule and routine'.

Lastly, Jean was talking about improvement of children's gross motor skills and she said:

> '*Child 1 was participating in activities that he would find very hard before. He climbs on chairs, desks…everywhere [laugh]! He participates more in highly demanding physical activities and he started climbing up the stairs'.*

The theme that was chosen here was 'other skills development'. However, it is essential to mention the subthemes that emerged through the data. The references teachers were making were related to two main skill sets. The first was social play, such as group play. References were clearly made about children that used to play alone and wanted to join in without knowing how. By the end of the study these children seemed to be more willing to participate in social activities. The second skill set was adaptive behaviours. Both Susan and Jean indicated the importance of adaptive behaviour skills, such as gross motor skills adaptation and adaptation to rules. Therefore, a new research question was added and the researcher evaluated those skills in both groups. The findings regarding those skills are presented later in this chapter.

6.8.4.3 Potential of Pictogram Room to be used for collaboration between teachers and occupational therapists

In their interviews, the teachers referred to the difficulty of not having an occupational therapist full-time at the school and also that even when he or she does come, the sessions do not last more than 10 to 15 minutes. Jean said:

‘We love having an occupational therapist around, only it doesn’t happen. As a school we don’t have the funding or the necessary equipment. It’s great to have a tool [referring] to Pictogram Room] that we can use independently but imagine the potential. I mean if we were using it with OT’s (Occupational Therapist) input.’

Susan also mentioned:

‘*We can’t have proper occupational therapy at the school. We don’t have the equipment for that. I see Pictogram Room to be used in collaboration with OTs. We can have programmes together with the kids and we could even work all together in the classroom’.*

The points made by the teachers were very important, as they revealed the need for having occupational therapists working in collaboration with them, but they also addressed very important issues. The issues that emerged from the interviews related to the shortage of occupational therapy at the school, lack of specialised equipment, restricted funding and space concerns. They also made a very powerful statement regarding the actual close collaboration between teachers and the occupational therapist, to better assist their students.

Table 17: List of themes, and examples of concepts coded

Themes Predefined	Sub-themes	Concepts coded
1.Overall Sensory-Motor development	*a. Influences*	e.g. Uncertainty of difference between some children who received the intervention compared to their peers, occupational therapy at the same time, maturation, generalisation issues to all school environments
	b. Effectiveness	e.g. all children benefited, his overall sensory-motor development is amazing, more confident in movement
2.Effects of Different Environments	*a. Physical Education*	e.g. great improvement, structure
	b. Classroom	e.g. not obvious changes
	c. Playground	e.g. least improvement, less control, not structured activities
	d. Software	e.g. The greatest change
	a. Balance and Motion	e.g. improved, physically demanding activities

3.Sensory-Motor Sub-domains	*b. Body Awareness*	e.g. greatest improvement, aware of others, aware of own body in space
	c. Planning and Ideas	e.g. not obvious changes, sequencing, poor motor coordination when writing
Emerged		
4.Further Development and Implementation	*a. Study implementation*	e.g. child playing with peer, interaction, friendships formation, inclusion
	b. Other Skills Development	social play: e.g. Join group activities, solitary play, afraid of games to join in adaptive behaviours: e.g. following classroom rules, following instructions, adapting to classroom schedule and routines, gross motor adaptation to physically demanding activities
	c. Potential of Pictogram Room to be used for collaboration between teachers and occupational therapists	e.g. difficulty having an occupational therapist full-time at the school, 10 to 15 minutes sessions, lack of funding and necessary

6.9 Results on social play across all environments between the intervention and the control group

As mentioned previously, the researcher developed the Social Play Assessment (SPA) to measure the frequency and the duration of children's participation in group, parallel, or solitary play, or being unoccupied/neutral. The video recordings that were used were from three different environments (i.e. PE, Classroom and Playground). The researcher wanted to find out whether there were differences between the intervention and the control group in their social play, as indicated through the teacher's interviews during Phase I.

6.9.1 Results on frequency of social play from SPA

Table 18: Results on frequency of social play from SPA

		Group						
		Intervention (n=5)		**`Control (n=5)**				
		Mean	**SD**	**Mean**	**SD**	**t**	**p**	**Cohen's d**
Before-intervention	**Group**	5.4	1.94	5	1.58	0.3885	0.7174	0.22
	Parallel	14	2.73	13.8	3.42	0.1048	0.9216	0.06
	Solitary	11.2	3.11	11.4	3.2	0.1667	0.8757	0.06

	Neutral	4	1.87	4.6	2.07	0.4966	0.6455	0.3
After-intervention	**Group**	7	1.58	6.2	1.09	1.2060	0.2943	**0.6**
	Parallel	13.8	2.28	14	1.87	0.2500	0.8149	0.1
	Solitary	7.2	2.16	9.2	3.27	1.5811	0.1890	**0.72**
	Neutral	2.6	1.51	3.2	1.3	1	0.3739	0.42

To assess the frequency of social play in the two groups, before and after the intervention, a paired t-test was conducted. No significant differences were found between the two groups after the intervention (Group: Intervention group: M=7, SD=1.58; Control group: M=6.2, SD=1.09; t(4)= 1.2060, p=0.2943; Parallel: Intervention group: M=13.8, SD=2.28; Control group: M=14, SD=1.87; t(4)=0.25, p=0.8149; Solitary: Intervention group: M=7.2, SD=2.16; Control group: M=9.2, SD=3.27; t(4)=1.5811, p=0.1890; Neutral: Intervention group: M=2.6, SD=1.51; Control group: M=3.2, SD=1.3; t(4)=0.3739, p=0.42). Although there were improvements, and the intervention group had a bigger difference with the control group, compared to the baseline, the differences were still not apparent. However, after calculating the Cohen's d effect sizes there was a medium effect for the group play (Cohen's d=0.6) and solitary play was decreased for the intervention group (Cohen's d=0.72).

6.9.2 Results on duration of social play from SPA

Table 19: Results on duration of social play from SPA

		Group						
		Intervention (n=5)		**`Control (n=5)**				
		Mean	**SD**	**Mean**	**SD**	**t**	**p**	**Cohen's d**
Before-intervention	**Group**	794.8	175.37	766.6	177.33	0.8857	0.4258	0.16
	Parallel	1826.4	220.69	1839.4	389.97	0.0787	0.9411	0.04
	Solitary	2017.6	313.24	1945	184.83	0.5068	0.6389	0.28
	Neutral	854.8	248.97	808.6	221.34	0.4018	0.7084	0.19
After-intervention	**Group**	1673.6	308.6	1338.6	200.77	2.0235	0.1130	1.28
	Parallel	2151.8	257.16	1958.8	178.1	1.5189	0.2034	0.87
	Solitary	1218.8	421.4	1646.6	418.07	1.2581	0.2768	1.01
	Neutral	394.4	252.6	437.8	129.64	0.2751	0.7969	0.21

To assess the duration of social play in the two groups, before and after the intervention, a paired t-test was conducted. No statistically significant differences were found between the two groups after the intervention (Group: Intervention group: M=1673.6, SD=308.6; Control group: M=1338.6, SD=200.77; t(4)= 2.02, p=0.11; Parallel: Intervention group:

M=2151.8, SD=257.16; Control group: M=1958.8, SD=178.1; t(4)=1.51, p=0.20; Solitary: Intervention group: M=1218.8, SD=421.4; Control group: M=1646.6, SD=418.07; t(4)=1.25, p=0.27; Neutral: Intervention group: M=394.4, SD=252.6; Control group: M=437.8, SD=129.64; t(4)=0.27, p=0.79). Although there were improvements, and the intervention group had a bigger difference with the control group, compared to the baseline, the differences were still not apparent. However, after calculating the Cohen's d effect sizes, there was a large effect for the group play (Cohen's d=1.28) and Parallel play (Cohen's d= 0.87), and Solitary play was decreased for the intervention group (Cohen's d=1.01). The neutral state was about the same for the two groups (Cohen's d=0.21).

6.10 Results on social play in each environment between the intervention and the control group

For this part, the children were filmed in PE, classroom (i.e. free play activities) and playground. For both groups, 30-minute video segments, before and after the duration of the intervention, were chosen to be coded. Therefore, the total video coded time for each child was three hours, across all three environments. The results for the social play in each environment are presented below.

6.10.1 Social play frequency in PE

Table 20: Social play frequency in PE

		Group						
		Intervention (n=5)		**`Control (n=5)**				
		Mean	**SD**	**Mean**	**SD**	**t**	**p**	**Cohen's d**
Before-intervention	**Group**	3.4	1.14	3.2	1.6	0.2325	0.8276	0.14
	Parallel	4.4	2.3	4.2	1.6	0.2063	0.8466	0.1
	Solitary	3.2	1.64	3.6	0.89	0.4924	0.6483	0.3
	Neutral	1.6	1.14	1.8	1.3	0.3430	0.7489	0.16
After-intervention	**Group**	3.8	0.83	3.6	1.14	0.4082	0.7040	0.2
	Parallel	3.2	1.48	4.4	1.14	1.4343	0.1894	0.9
	Solitary	1.6	1.14	2.2	0.83	1.1767	0.3046	0.6
	Neutral	1.2	0.44	1.2	0.84	0	1	0

To assess the frequency of social play in the two groups, before and after the intervention, in the PE environment, a paired t-test was conducted. No statistically significant differences were found between the two groups after the intervention (Group: Intervention group: M=3.8, SD=0.83; Control group: M=3.6, SD=1.14; t(4)= 0.40, p=0.70; Parallel: Intervention group: M=3.2, SD=1.48; Control group: M=4.4, SD=1.14; t(4)=1.4343, p=0.1894; Solitary: Intervention group: M=1.6, SD=1.14; Control group: M=2.2, SD=0.83; t(4)= 1.1767, p=0.3046; Neutral: Intervention group: M=1.2, SD=0.44; Control group: M=1.2, SD=0.84; t(4)=0, p=1). Although there were improvements, and the intervention group had a bigger difference with the control group, compared to the baseline, the differences were still not significant. However, after calculating the Cohen's d effect sizes, there was a large effect size for the parallel play (Cohen's d=0.9) and solitary play was decreased for the intervention group (Cohen's d=0.6).

6.10.2 Social play duration in PE

Table 21: Social play duration in PE

		Group						
		Intervention (n=5)		**`Control (n=5)**				
		Mean	**SD**	**Mean**	**SD**	**t**	**p**	**Cohen's d**
Before-intervention	**Group**	477.4	105.23	456.2	154.9	0.4931	0.6478	0.16

	Parallel	672.6	187.2	702.6	176.14	0.3249	0.7616	0.16
	Solitary	480	132.16	457.6	91.38	0.8326	0.4519	0.19
	Neutral	170	94.68	183.6	94.18	0.2285	0.8304	0.14
After-intervention	**Group**	994	214.35	772.6	169.4	1.8494	0.1381	1.14
	Parallel	500.2	160.41	527.2	96.94	0.4889	0.6505	0.2
	Solitary	179.2	152.12	370.4	233.13	1.8543	0.1373	0.97
	Neutral	126.6	63.99	150.2	63.31	0.5401	0.6178	0.37

To assess the duration of social play in the two groups, before and after the intervention, a paired t-test was conducted. No statistically significant differences were found between the two groups after the intervention (Group: Intervention group: M=994, SD=214.35; Control group: M=772.6, SD=169.4; t(4)= 1.84, p=0.13; Parallel: Intervention group: M=500.2, SD=160.41; Control group: M=527.2, SD=96.94; t(4)=0.48, p=0.65; Solitary: Intervention group: M=179.2, SD=152.12; Control group: M=370.4, SD=233.13; t(4)=1.85, p=0.13; Neutral: Intervention group: M=126.6, SD=63.99; Control group: M=150.2, SD=63.31; t(4)=0.54, p=0.61). Although there were improvements, and the intervention group had a bigger difference with the control group, compared to the baseline, the differences were still not apparent. However, after calculating the Cohen's d effect sizes, there was a large effect for the group play (Cohen's d=1.14) and Solitary play was decreased for the intervention group (Cohen's d=0.97). The neutral state and parallel play were very similar between the two groups (Cohen's d=0.37 and Cohen's d=0.2 respectively).

6.10.3 Social play frequency in the classroom

Table 22: Social play frequency in the classroom

		Group						
		Intervention (n=5)		**`Control (n=5)**				
		Mean	**SD**	**Mean**	**SD**	**t**	**p**	**Cohen's d**
Before-intervention	**Group**	1.8	0.83	1.6	0.54	0.5345	0.6213	0.28
	Parallel	8.8	1.4	8.6	1.6	0.25	0.8149	0.12
	Solitary	6.4	1.8	6	2	0.3739	1	0.2
	Neutral	1.4	0.89	1.6	0.54	0.3430	0.789	0.26
After-intervention	**Group**	2.6	0.54	2.2	0.83	0.7845	0.4766	0.56
	Parallel	7.8	1.3	7.4	1.5	0.5898	0.5870	0.28
	Solitary	4.4	0.8	5	2	0.8847	0.4263	0.38
	Neutral	0.4	0.54	0.8	0.83	1.6330	0.1778	0.56

To assess the frequency of social play in the two groups, before and after the intervention, in the Classroom environment, a paired t-test was conducted. No statistically significant differences were found between the two groups after the intervention (Group: Intervention Group: M=2.6, SD=0.54; Control group: M=2.3, SD=0.83; t(4)=0.7845, p=0.4766; Parallel: Intervention Group: M=7.8, SD=1.3; Control group: M=7.4, SD=1.5; t(4)=0.5898, p=0.5870; Solitary: Intervention Group: M=4.4, SD=0.8; Control group: M=5, SD=2; t(4)= 0.8847, p=0.4263; Neutral: Intervention Group: M=0.4, SD=0.54; Control group: M=0.8, SD=0.83; t(4)=1.6330, p=0.1778). Cohen's d effect sizes were also calculated and revealed small effect sizes between the two groups for parallel and solitary play. Neutral state and group play had medium effect, with the intervention group engaging more in group play than the control group, and the control group being more often in neutral state, compared to the control group.

6.10.4 Social play duration in the classroom

Table 23: Social play duration in the classroom

		Group						
		Intervention (n=5)		`Control (n=5)				
		Mean	**SD**	**Mean**	**SD**	**t**	**p**	**Cohen's d**
Before-intervention	**Group**	304.8	88	289.2	112	0.7201	0.5113	0.15
	Parallel	833.4	247.71	883.4	157.63	0.9841	0.3808	0.24
	Solitary	411.8	166.59	408	75.95	0.0890	0.9334	0.02
	Neutral	250	116.67	219.4	78.85	1.6858	0.1671	0.3
After-intervention	**Group**	535.6	102.42	504.8	64.65	0.6081	0.5759	0.35
	Parallel	797.2	51	758.6	68.97	0.8368	0.4498	0.63
	Solitary	441.4	179.86	437.6	89.81	0.0372	0.9721	0.02
	Neutral	64.4	112.15	60.4	60	0.1127	0.9157	0.04

To assess the duration of social play in the two groups, before and after the intervention, a paired t-test was conducted. No statistically significant differences were found between the two groups after the intervention (Group: Intervention group: M= 535.6, SD= 102.42; Control group: M= 504.8, SD= 64.65; t(4)= 0.60, p= 0.57; Parallel: Intervention group: M= 797.2, SD= 51; Control group: M= 758.6, SD= 68.97; t(4)= 0.83, p= 0.44; Solitary: Intervention group: M=441.4, SD=179.86; Control group: M= 437.6, SD= 89.81; t(4)= 0.03, p= 0.97; Neutral: Intervention group: M= 64.4, SD= 112.15; Control group: M= 60.4, SD= 60; t(4)= 0.11, p= 0.91). After calculating the Cohen's d effect sizes, there was a small effect for group play (Cohen's d= 0.35) and almost no effect for solitary play and neutral state (Cohen's d= 0.02 and Cohen's d= 0.04) Parallel play, however, had a medium effect size (Cohen's d= 0.63) with the intervention group engaging more, compared to the control group.

6.10.5 Social play frequency in the playground

Table 24: Social play frequency in the playground

		Group						
		Intervention (n=5)		**`Control (n=5)**				
		Mean	**SD**	**Mean**	**SD**	**t**	**p**	**Cohen's d**
Before-intervention	**Group**	0.2	0.44	0.2	0.44	0	1	0
	Parallel	0.8	0.84	1	1.22	0.2325	0.8276	0.19
	Solitary	1.6	0.89	1.8	0.83	0.5345	0.6213	0.2
	Neutral	1	0.7	1.2	0.44	0.5345	0.6213	0.3
After-intervention	**Group**	0.6	0.54	0.4	0.54	1	0.3739	0.36
	Parallel	2.8	0.83	2.2	0.83	1.1767	0.3046	0.7
	Solitary	1.2	0.44	2	0.7	2.1381	0.0993	1.3
	Neutral	1	0.7	1.2	0.83	0.5345	0.6213	0.25

A paired t-test was conducted to compare the two groups' frequency of social play, before and after the intervention, in the Playground. No statistically significant differences were found between the two groups after the intervention After intervention; (Group: Intervention Group: M=0.6, SD=0.54; Control group: M=0.4, SD=0.54; t(4)=1, p=0.3739; Parallel: Intervention Group: M=2.8, SD=0.83; Control group: M=2.2, SD=0.83; t(4)=1.1767, p=0.3046; Solitary: Intervention Group: M=1.2, SD=0.44; Control group: M=2, SD=0.7; t(4)= 2.1381, p=0.0993; Neutral: Intervention Group: M=1, SD=0.7; Control group: M=1.2, SD=0.83; t(4)=0.5345, p=0.6213). However, the Cohen's d effect sizes that were also calculated and revealed a large effect size (Cohen's d=1.3) between the two groups for solitary play, with the intervention group engaging less frequently, compared to the control group. A medium to large effect size (Cohen's d=0.7) was revealed for parallel play, with the intervention group participating more. Neutral state and group play had small effect sizes (Cohen's d= 0.25 and Cohen's d= 0.36.

6.10.6 Social play duration in the playground

Table 25: Social play duration in the playground

		Group						
		Intervention (n=5)		**`Control (n=5)**				
		Mean	**SD**	**Mean**	**SD**	**t**	**p**	**Cohen's d**
Before-intervention	**Group**	12.6	28.17	21.2	29.03	0.4006	0.7092	0.3
	Parallel	226.6	222.74	253.4	181.18	0.2100	0.8439	0.13

	Solitary	1125.8	111.42	1079.8	177.43	0.4593	0.6699	0.3
	Neutral	435	200.23	446	138.19	0.1128	0.9157	0.06
After-intervention	**Group**	144	154.59	61.2	86.1	1.6177	0.1810	0.66
	Parallel	854.4	187.64	673	178.38	1.3254	0.2557	0.9
	Solitary	598.2	219.29	838.6	153.41	1.5981	0.1853	1.27
	Neutral	203.4	142.89	227.2	163.76	0.1754	0.8693	0.15

A paired t-test was conducted to assess the duration of social play in the two groups, before and after the intervention, for the Playground environment. No statistically significant differences were found between the two groups after the intervention (Group: Intervention group: M=144, SD=154.59; Control group: M=61.2, SD=86.1; t(4)= 1.61, p=0.18; Parallel: Intervention group: M=854.4, SD=187.64; Control group: M=673, SD=178.38; t(4)=1.32, p=0.25; Solitary: Intervention group: M=598.2, SD=219.29; Control group: M=838.6, SD=153.41; t(4)=1.59, p=0.187; Neutral: Intervention group: M=203.4, SD=142.89; Control group: M=227.2, SD=163.76; t(4)=0.17, p=0.86). However, Cohen's d effect sizes calculations revealed a medium effect for the group play (Cohen's d=0.66) and large effect size for parallel play (Cohen's d= 0.9), with the intervention group participating in this type of play for longer. Solitary play was decreased for the intervention group (Cohen's d=1.27). The neutral state was about the same for the two groups (Cohen's d=0.15).

6.11 Results on adaptive behaviour between the intervention and the control group

Table 26: Results on adaptive behaviour between the intervention and the control group

		Group						
		Intervention (n=5)		`Control (n=5)				
		Mean v-score	SD	Mean v-score	SD	t	p	Cohen's d
Before-intervention	**Communication**	33.6	2.4	32.4	3.4	1.32	0.278	0.4
	Receptive	11	1	11.2	1.64	0.272	0.799	0.14
	Expressive	8.6	0.54	8.4	0.54	1.0	0.373	0.3
	Written	14	2.54	12.8	1.9	0.637	0.558	0.5
	Daily Living Skills	32.4	2.3	31.8	0.84	1.809	0.144	0.3
	Personal	9.2	1.09	8.8	0.83	0.784	0.476	0.4

	Academic	13	1	12.2	1.6	0.93	0.405	0.5
	School Community	10.2	1.92	10.8	1.3	0.647	0.552	0.3
	Socialisation	29.2	3.7	29	2	0.278	0.794	0.06
	Interpersonal Relationships	8.8	1.3	8.6	0.54	0.301	0.778	0.2
	Play and leisure time	9.6	1.1	9.6	0.89	0	1	0
	Coping skills	10.8	1.6	10.6	2.07	0.343	0.748	0.1
	Motor	18.2	1.3	17.6	2.41	0.582	0.591	0.3
	Gross	8.4	1.31	8.4	1.81	0	1	0
	Fine	9.8	0.44	9.2	0.83	2.449	0.070	0.8
After-intervention	**Communication**	35.6	2.88	34.4	2.61	0.539	0.617	0.4
	Receptive	12.2	0.8	12	1.2	0.343	0.748	0.2

Expressive	9	0.7	9	0.7	1	0	0
Written	14.4	2.4	13.4	1.8	0.568	0.6	0.4
Daily Living Skills	38.8	2.17	35.8	2.17	3.354	0.028	1.3
Personal	11.6	1.34	10.6	1.14	1.1	0.326	0.8
Academic	14.6	1.14	13.8	1.48	1.372	0.242	0.6
School Community	12.6	1.67	11.4	1.3	1.50	0.208	0.79
Socialisation	34.6	3.6	30.8	2.04	3.354	0.028	1.2
Interpersonal Relationships	10.8	2.1	9.4	0.55	1.247	0.28	0.88
Play and leisure time	11.4	1.1	10.2	0.8	1.5	0.208	1.2
Coping skills	12.4	1.5	11.2	1.6	3.207	0.032	0.76
Motor	21.8	1.09	19.4	2.19	3.207	0.032	1.3

Gross	10.8	1.3	9.2	1.6	2.82	0.047	1.07
Fine	10.8	0.86	10.4	0.89	1.633	0.177	0.46

A paired t-test was conducted to see the changes in children's adaptive behaviour. The two matched participant groups were tested before and after the intervention. As seen from the table, before the intervention the two groups are quite similar across all four domains and subdomains of VABS (Communication: Intervention group: M=33.6, SD=2.4; Control group: M=32.4, SD=3.4; t(4)=1.32, p=0.278; Daily living skills: Intervention group: M=32.4, SD=2.3; Control group: M=31.8, SD=0.84; t(4)=1.809, p=0.144; Socialisation: Intervention group: M=29.2, SD=3.7; Control group: M=29, SD=2; t(4)=0.278, p=0.794; Motor: Intervention group: M=18.2, SD=1.2; Control group: M=17.6, SD=2.41; t(4)=0.582, p=0.591). This is also evident through the Cohen's d effect sizes calculations that were 0.4, 0.3, 0.06 and 0.3 for the domains of Communication, Daily living skills, Socialisation and Motor respectively.

After the intervention the two groups were different in their adaptive skills. The paired t-test showed that there were no significant differences between them in the Communication domain (Intervention group: M=35.6, SD=2.88; Control group: M=34.4, SD=2.61; t(4)=0.539, p=0.617) but there were significant differences in the other three domains (Daily living skills: Intervention group: M=38.8, SD=2.17; Control group: M=35.8, SD=2.17; t(4)=3.354, p=0.028; Socialisation: Intervention group: M=34.6, SD=3.6; Control group: M=30.8, SD=2.04; t(4)=3.354, p=0.028; Motor: Intervention group: M=21.8, SD=1.09; Control group: M=19.4, SD=2.19; t(4)=3.207, p=0.032). These results also reflect the Cohen's d effect sizes, which are Communication effect size=0.4, Daily living skills effect size=1.3, Socialisation effect size=1.2 and Motor effect size=1.3.

6.12 Summary

This Chapter presented the findings on how using Pictogram Room impacted upon children's sensory motor development. It also, addressed the development of these skills across different environments, to see whether they can be generalised. Additionally, there were results on sensory-motor sub-domains to explore, which may have improved further. These results were initially presented separately for the intervention group and then presented as a comparison between the intervention and the control group. Furthermore, results from teachers' interviews were presented on how the study could further be informed, and also additional information on further skill development. To add to that, the findings regarding social play and adaptive behaviours between the two groups were also reported.

All children increased their sensory-motor score and as a group were quite homogenous. With regard to the generalisation extent to other environments, results were mixed. Within the software environment was the greatest difference, that was supported both from the quantitative and qualitative data. With reference to the other environments, PE was reported as the environment that the children presented the greatest sensory-motor development, and the playground the least. However, the effect sizes (Cohen's d) ranged from medium to large, suggesting that there were changes in children's sensory-motor skills across all settings. Whereas the teachers expressed concerns about the generalisability, drawing attention to the children's natural maturation. Additionally, children's score on sensory-motor subdomains was explored. The teachers suggested that children's body awareness was enhanced the most in this subdomain, compared to balance and planning. This was in contrast to the quantitative data, which suggested planning skills to have improved the most. The last part of the interviews included results from teachers' interviews on general things about the study. This mostly concerned the study implementation, other skills developed and the potential that Pictogram Room could be used as a tool to enhance collaboration between teachers and occupational therapists. Teachers suggested using Pictogram Room with peers, rather than an adult and a child. They also expressed their concern again on generalisation of sensory-motor skills development in other environments. Furthermore, they highlighted the development of other skills that were not initially targeted in the study, such as participation in social activities, gross motor skills, adapting to routines and social situations. They also expressed the need to have an occupational therapist full-time at the school, and how they could collaborate using Pictogram Room as a tool for the sensory-motor development of their students. Finally, results on social play and adaptive behaviour were presented, derived as a recommendation from the teachers' interviews. Regarding social play, although there were no statistically significant differences between the two groups, the Cohen's d effect sizes suggested that the control group reduced the amount of time spending in neutral state and solitary play, and started participating more in parallel and group play. Finally, in terms of the children's adaptive behaviours, the intervention group presented significant differences in the daily living skills, socialisation and motor domains, compared to the control group. The next Chapter discusses the findings of the study.

CHAPTER 7

DISCUSSION

7.1 Introduction

Despite the growing prevalence of sensory-motor skills difficulties in individuals with autism, there are only a few studies that focus on developing interventions that target this area. There are even fewer when it comes to TEL interventions doing the same. Most studies using TEL intervention for autism have focused mainly on social communication skills, language development, academic and daily living skills (Grynszpan et al., 2013; Boser, Goodwin and Wayland, 2014). With the recent technology advances and new platforms for gaming, new tools have become available for use with TEL interventions, such as the Nintendo Wii and the Microsoft/Xbox Kinect. Exergames is the name that has been proposed recently (e.g. Hilton et al., 2014) for the games played using those tools, as they allow full body input and promote physical activity. Even studies that used these games have mostly focused on social communication skills, fitness levels, gross motor skills, cognitive skills and restricted and repetitive behaviour (Goble et al., 2014). Although these types of skills are understandably crucial and predominant in individuals with autism, sensory-motor skill development plays a very important role and assists in many of these aspects. Skills like balance, body awareness and motor-planning, that the researcher looked at, are very important for the individuals' everyday life, as they help them navigate their environment better and assist them in daily life tasks, which in turn can enhance a range of skills. For example, if a child has better motor-planning, they might be able to perform better on sequencing games (e.g. picking up a ball, hit a target, pick up the ball and give it to someone else) and thus be able to participate in more activities with his or her friends.

In this chapter the findings of the study are discussed along with how Pictogram Room has contributed to the development of the children's sensory-motor skills. The discussion starts with the effectiveness of the software and the factors that have possibly contributed to that. Then there is a discussion on the generalisation of children's skills across different school environments, and what aspects might influence the generalisation. Continuing from that, there is a discussion on children's scores on the three sensory-motor sub-domains (i.e. Balance and Motion, Body Awareness and Planning and Ideas). Additionally, there is a discussion on the information teachers gave through the interviews for the intervention group on sensory-motor skills. After this, there is a discussion from the teachers' interviews, regarding the further implementation of the study, a discussion on how the interviews were different from the quantitative data, and how the interviews gave new insights for the study. Furthermore, the findings on children's social play and adaptive behaviours are discussed. Additionally, building on the interviews with the teachers, a discussion of the implications of the intervention in the school setting are discussed. More specifically, the feasibility and the different methods of Pictogram Room implementation are discussed. Furthermore, there is a discussion on how teachers can collaborate with occupational therapists using Pictogram Room, to further enhance their students' skills. The chapter concludes with a discussion on conducting experimental designs in school settings, drawing upon issues relating to the research and practice gap that exists, and the importance of the practitioners' involvement.

7.2 Effectiveness of Pictogram Room on sensory-motor development

One of the main aims of the study was to investigate whether Pictogram Room could be used as an effective intervention for sensory-motor development of children with autism. Although there is much scientific evidence supporting the benefits of augmented reality (AR) for children with autism (Bai et al. 2013; Escobedo et al., 2014), studies exploring the effect of AR using Kinect-based gaming technology in children with autism are still limited. The results of this study indicate that a group of children with autism showed significantly improved sensory-motor skills after using the Pictogram Room over a period of 18 weeks. This improvement was noted in relation to their pre-intervention skills, and when compared to a control group observed over the same period of time.

It is hard to compare the findings of this study with other studies, as the researcher has not found other studies using a technology intervention to support the development of sensory-motor skills in children with autism, which were implemented in a school setting. There might be various reasons as to why studies with the same focus and methodology could not be identified. First of all, the definition of sensory-motor skills used in this study understands the children's motor issues as a result of sensory integration issues, whereas other authors consider the motor aspect and the sensory aspect separately (Baranek, 2002). In addition, most studies looking specifically at using technology to support the development of children's sensory-motor skills have focused on children with other conditions and not autism, such as cerebral palsy (e.g. Patel, 2005; Zadnikar et al., 2011), Down Syndrome (e.g. Rahman, 2010; Wuang et al., 2011) and learning difficulties (e.g. Schaaf and Miller, 2005). Finally, Kinect-based activities are quite new, and although some aspects of sensory-motor skills such as body awareness have been addressed (e.g. Zalapa and Tentori, 2013), there is not yet a Kinect-based intervention that has been used to address the execution of these skills (i.e. planning). Most technologies used in studies in this field are in a prototype format and have not being tested with participants (Munson and Pasqual, 2012).

Sensory Integration (SI) therapy is the main intervention that understands sensory-motor skills as they were defined in this study. In a randomised control study looking at the effectiveness of SI therapy for children with autism aged 6-12, Pfeiffer et al. (2011) compared 20 children receiving SI therapy, with 17 children receiving a fine motor skills intervention. Assessing the children after 18 sessions (which is similar to the 18 sessions used in this study), they found low to moderate differences between the groups when using Goal Attainment Scaling and when using the SPM. Studies using SI therapy as the intervention approach for developing sensory-motor skills tend to include small numbers of participants (i.e. <10) (e.g. Bagatell et al., 2010) or be single-case studies (e.g. Bonggat and Hall, 2010). This means that these studies' reports of significant changes need to be treated with caution as they do not control for children's natural maturation, or the effect of other interventions received by the participants. On the other hand, these studies illustrate how highly individualised SI therapy programmes, like those used in these small scale studies, can be very beneficial to the development of sensory-motor skills in children with autism. This is because these interventions were tailored to the needs of each participant (Case-Smith and Arbesman, 2008). In the present study, the researcher was able to use Pictogram Room in a way that met every child's individual sensory-motor needs, resulting in significant improvements. This seems to support the need for a high level of individualisation of this type of programme. As Case-Smith et al. (2014), suggest the mismatch between the goals of sensory integration-based interventions (e.g. weighted vests) and children's learning needs is one of the main factors negatively impacting on the effectiveness of this type of interventions compared to SI therapy, which by definition is always closely tailored to individual needs. Pictogram Room followed the SI therapy paradigm, meaning that it could be adapted to children's individual needs, their everyday school activities, and their specific sensory-motor profiles.

It is also important to note that significant improvements in sensory-motor skills might have arisen through a series of training steps that were followed throughout the use of Pictogram Room. These steps were structured, goal-directed, and progressive. For instance, Child 3 first learnt how to place his body, so as to be visible by the Kinect camera. Once he mastered simple activities involving moving left or right, more challenging and dynamic games were introduced, such as: jumping, balancing and catching balls. Wuang et al. (2011) followed this paradigm when designing and implementing a Virtual Reality (VR) Wii platform for children with Down Syndrome, moving from simple to more complex movement activities. The total number of participants was 105 (7-12 years old) and they were randomly assigned to the intervention group using VRWii, while the other group followed a programme of traditional occupational therapy. Post-intervention an overall Cohen's d effect size of bigger than 0.8 was noted between the two groups in sensory-motor, visual perception and motor coordination assessments.

Another important aspect of the use of Pictogram Room is that the Kinect camera promoted an optimal sensory input, by allowing the children to explore and organise different sensory mechanisms. This means that the children did not work with isolated parts of their body (e.g. only their hands) or isolated sensory modalities (e.g. vestibular) but there was a combination of the whole body movement and a combination of sensory modalities like the vestibular, proprioceptive and visual systems. Additionally, the use of the Kinect camera allowed children to interact with a simulated game environment, and to receive real-time augmented feedback of their body positioning and performance. Root et al. (2015) in their study report that after using a mirror for visual feedback with an adolescent with autism, found improvements in his gait. Therefore, after mastering Pictogram Room activities, the children were able to use body feedback to understand the movement outcomes, anticipate upcoming steps and plan new and/or alternative strategies. By adjusting the difficulty levels of Pictogram Room activities, more mature patterns of sensory-motor skills emerged. This was further supported by the constant visual feedback the children received, as it was a process through which the child learned to rely on a self-correction process, rather than external feedback. This is in line with previous findings regarding benefits of TEL for individuals with autism, that have highlighted the opportunity for individuals with autism to practice skills and correct themselves (Goldsmith and LeBlanc, 2004; Parsons and Mitchell, 2002; Rizzo and Kim, 2005).

An essential component of all the movements experienced in Pictogram Room similarly to other free body movement technologies (e.g Wii Sports), is proactive somatosensory control (Augurelle, Smith and Lejeune, 2003; Jeannerod, 1990). This is related to the execution of movements and planning (Johansson, 1998; Whitney et al., 2004). Therefore, the motor tasks involved in the intervention have led to a greater improvement of sensory-motor skills. Kinect-based games can provide constant opportunities for children to integrate planning, vestibular, and proprioceptive inputs (Bartolli et al., 2013). In particular, the play element and the active participation in goal-directed and enjoyable activities, can maximise the intervention's effects (Larin, 2000; Parham, Mailloux and Case-Smith, 2005). This is also in line with the theoretical background of using gamification along with embodied experiences to teach a set of new skills. The rationale behind using this two approaches for choosing Pictogram Room as the tool for the intervention, is not only supported by the literature but it was evident in the teachers' interviews as well. They both mentioned how fun and engaging the game was and the children were working on the sensory-motor skills without realising they were being taught. Pictogram Room's principle of using playful, meaningful and challenging activities, in order to increase sensory-motor skills coincides with the principles of sensory integration theory proposed by Dr J. Ayres (Ayres, 1972; Jacobs and Schneider, 2001), that introduces simple activities targeting those behaviours, which gradually get harder, with the children always getting feedback for their actions enabling them to adjust their body accordingly.

However, one must be cautious about the interpretation of the data and the effectiveness of the intervention, as, although Pictogram Room seems to hold great potential, this might be due to the small sample size and the research design that was followed by the researcher. For example, when looking only the data on the Playground for the intervention group, their improvements in sensory-motor skills were significant, but not when they were compared to a control group. That can be supported by other studies that tested the efficacy of SI therapy when different experimental designs were followed. The researcher picked SI therapy as a comparison paradigm, as it is the most well documented intervention for sensory-motor skills in autism (Case-Smith et al., 2014). In the early years of SI therapy, mostly A-B single-subject designs were followed, as the researcher did, to evaluate sensory-motor skills in the intervention group alone. The results from these studies showed significant improvements, not only in sensory-motor domains, but also in other domains, including severity of autism symptoms, play, engagement and social interactions (Case-Smith and Bryan, 1999; Linderman and Steward, 1999; Bagatell et al., 2010; Neysmith-Roy, 2011). On the other hand, in studies that utilised control-group designs, the results were mixed, with some studies showing large effects (Edelson et al., 1999; Rimland and Edelson, 1995; Fazlioglu and Baran, 2008) and others showing low to moderate effects (Bettison, 1996; Zollweg, Palm and Vance, 1997; Smith et al., 2005; Piravej et al., 2009). One possible explanation could be that it is hard to control for other interventions taking place at the same time (Cohen et al., 2011). These interventions might be for the intervention group, but for the control group as well. As the researcher was not able to conduct an interview with the teacher of the children in the control group, she was not aware of other interventions taking place, and this might have led this group to perform, in many cases, at the same level as the intervention group. The teachers of the intervention group reported that, during the intervention stage, a child started occupational therapy. Other children might have been receiving occupational therapy, or other types of intervention, that the teachers were not aware of, and these interventions might have contributed to the sensory-motor skills improvements. The use of a control group, as they have equal chances of receiving other interventions as well, might control for this (Gersten et al., 2000) but the small sample size of both groups means that findings need to be considered with caution (Cohen et al., 2011).

7.3 Generalisation of sensory-motor skills across different environments

It was very important for the researcher to test the generalisability of the skills across different settings. For that reason, data for the intervention group was gathered not only in the Software environment, but also in three other school environments (PE, Classroom and Playground) and at Home. Additionally, interviews with teachers were used to give further insight into the children's use of sensory-motor skills across different school settings. The findings of the study reveal that the children generalised their sensory-motor skills to a great extent across different environments, although somewhat less in the Playground and at Home. Most studies using TEL interventions for autism have not tested for generalisation of skills outside the technology environment or, in many instances, no evidence was found for that occurrence (Richardson, 2015). The next two sections explore different aspects that may affect the generalisation of skills across different environments, when implementing an intervention.

7.3.1 Generalisation issues for technology interventions in autism

The difficulties that individuals with autism may have in demonstrating learned skills across different environments, can impact on their sensory-motor development. Though they may have mastered those skills in one environment, they may have limited ability to apply those skills in other settings (Plaisted, 2001). Challenges in generalisation can be present for several reasons. These may include poor flexibility, difficulty to relate a new skill to past experiences and difficulty in responding to cues (Hum, Loftin and Lantz, 2009). This study has shown that the children were able to generalise the skills learnt within the Software environment to other environments. However, it is important to investigate the aforementioned reasons that may lead to limited generalisation, and see what attempts were made to address this in the current research study.

Mental flexibility is an area in which individuals with autism present particular difficulties (Solomon et al., 2008). Recent research on cognitive functioning in autism addresses the potential impact it may have on one's ability to generalise (Hill, 2004). Individuals with autism may present difficulties in the ability to shift to different actions or thoughts, when the environment or the situation changes (Hill, 2004). These difficulties are not only specific to individuals with autism, but they can be intensified due to the methods and conditions with which students with autism tend to be taught (Jones, Lerman and

Lechago, 2013). This means that if the students are taught a new skill when stimulus and staff members are limited, and in settings which are irrelevant to the targeted skill, then this skill is less likely to be generalised (Hume, Loftin and Lantz, 2009).

In this study, the researcher worked closely with the teachers to pick activities from Pictogram Room that were relevant to the children's needs, and were aligned with skills they were working on in lessons. Also, Pictogram Room was not implemented in a lab environment but in a school classroom, which is a naturalistic environment where the children spend most of their time. Thus, it was much easier for them to transfer those skills to other environments in the school. Previous studies on SIB approaches have suggested a greater difficulty for generalisation of sensory-motor skills when the intervention took place in a naturalistic setting (Case-Smith et al., 2014). However, in their review, Case-Smith et al. (2014) pointed out that most of the times either these interventions were delivered by untrained staff or were not adjusted to children's needs.

Furthermore, it is suggested that individuals with autism have difficulties relating new stimuli to past experiences (de Marchena et al., 2015). This is due to their highly specific memory and their difficulty in integrating experiences. A slight change to the environment, such as a new location or new member of staff, may be significant to these individuals, causing them to become unable to recognise a stimulus. The response of an individual with autism to a specific stimulus may depend on the absence, or presence, of certain features in the environment. Thus, they may over-generalise if the feature is present in the current stimulus, or under-generalise if it is absent. Because of this stimulus over-selectivity in autism, if a small detail about the stimulus is altered in some way, such as the setting, materials or a person, the individual with autism may respond to it as a novel stimulus. Although the researcher in this study measured the same skills across different environments, the children did not seem to have difficulties in responding in the same way across different settings. This might be because the intervention took place in the children's natural setting. It could also be because the skills, which the children gained through the intervention, were applicable to other environments and they had the opportunity to present them.

Finally, Koegel and Koegel (1988) propose that lack of responsiveness to environmental stimuli may be another reason why children with autism have difficulties generalising skills and thus, difficulties presenting these skills independently, and in different locations. Children with autism can often find it difficult to respond to environmental stimuli, to shift from one stimulus to another, and also to relate one stimulus to another (Hume, Loftin and Lantz, 2009). This lack of responsiveness across multiple settings may negatively impact on their ability to generalise skills (Koegel and Koegel, 1988; de Marchena et al., 2015). Researchers have proposed that cognitive processing difficulties may play a role in unresponsiveness or over/under-generalisation in children with autism (Hume, Loftin and Lantz, 2009). These children may be using idiosyncratic or stereotypic strategies to process environmental stimuli, hence excluding functional processing of surroundings or experiences (Hume, Loftin and Lantz, 2009). To overcome this potential difficulty, the researcher, with help from the staff, identified the activities and the environments in which children would present sensory-motor behaviours relevant to their needs, as well as to the environments.

7.3.2 Impact of the level of structure on sensory-motor development

The most significant differences in the children's sensory-motor skills were observed in PE and in the Classroom, followed by the Home and Playground environments. In that sense, the skill development was noted to be greater in more structured environments, in which children follow specific routines, and less in unstructured environments, such as the Playground and Home. The researcher came across no previous studies that looked into sensory-motor skills according to different type of environments. However, there is similar evidence from studies on stereotypical behaviours that are closely related with sensory-motor development. A study by Prupas and Reid (2001) reports that if settings were more structured and, more specifically, in the classroom, children's stereotypical behaviours were significantly reduced. On the other hand, according to this study, unstructured environments, like the playground during free play, led to an increase in stereotypical behaviours. Studies examining social communication development in children with autism have resulted in mixed findings, with regards to whether structured or unstructured environments lead to greater social communication behaviours. Stone et al. (1997) found that in unstructured environments the children presented more social communication behaviours, and especially more initiation of communication. Whilst Chiang (2009) and O'reilly et al. (2005) found the opposite results, with the amount of social communication initiations being higher in more structured environments, such as in the classroom during academic activities.

One of the reasons for these different findings could the targeted skills themselves. Sensory-motor skills are more likely to be present when the environment is structured, as the children are required to perform specific actions. Hence there are more opportunities to observe these behaviours. For example, if one of the skills to observe is for the child to balance on one leg, there is a greater likelihood of observing this behaviour if the child is asked to perform it, or if the activity requires it to be completed. Furthermore, the location where the intervention is taking place is important. For instance, if the interventions work on targeted skills in the classroom, there may be a greater chance to observe them in that setting (Rao et al., 2008). In this study, the researcher conducted the intervention in the classroom, and this may be an important reason why more sensory-motor behaviours were observed there. It is crucial to note that although the intervention took place in a classroom environment, the greatest improvement was observed in PE, which is a non-classroom environment. This may be explained by the relevance of the activities and the behaviours being observed. Balance, body awareness and planning skills are directly targeted in PE, so the children have more chances to exhibit these behaviours there and, through the structured activities, perform better.

7.4 Sensory-motor sub-domain development

The third research question of this study was related to how much each of the sensory-motor sub-domains improved following the intervention. Results from BBAP and SPM showed that the three sensory-motor subdomains (i.e. Balance and Motion, Body Awareness and Planning and Ideas) were significantly improved for the intervention group. Planning and Ideas was the sub-domain that was improved more. The researcher expected to see improvements, since all three sub-domains complement each other.

Although other studies in sensory-motor interventions did not group these sub-domains all together, there has been evidence from various other interventions that targeted them separately. For example, kinematic studies involving dance therapy for autism have focused merely on body awareness (Edwards, 2015). Activities that require bodily input and movement have been examined previously for improvements regarding body part recognition and sense of the body in the environment (Srinivasan and Bhat, 2013). Recently, a Kinect-based game called Sensory Paint was developed specifically to promote body awareness in children with autism (Zalapa et al., 2013), and preliminary results showed that this can be an effective technique. Also, traditional SI therapy has been effectively used for promoting body awareness (Ayres, 1972). One possible explanation for the effectiveness of these interventions, as well as for Pictogram Room, might be the visual monitoring of the body while performing a task. For example, in dance therapy the instructors use the mirrors in the room, providing the children with visual feedback of the body movements they perform. Similarly, Pictogram Room offers visual body representation projected onto the white board through the Kinect camera, so that the child can see the actions he or she is performing.

In terms of balance skills, motion based touchless technologies like Nintendo Wii have been used in the past to promote those skills. Although there are no studies specific to autism, there is evidence from the elderly population (Saposnik et al., 2010) as well as other areas of special needs, including Down Syndrome (Wuang et al., 2011) and cerebral palsy (Tarakci et al., 2013) for its efficacy. Most of the studies in this area have used Wii Fit balance intervention with balance-specific activities. In most cases these balance activities were provided through commercially available games. To date, no study has reported negative results using the Wii Fit, and most of them have reported quantitative, or at least anecdotal, evidence of balance improvement (Globe et al., 2014; Santos et al., 2015). A small number of researchers have attempted to create their own games instead of using the standard Wii games. This is because these games can be customised to fit the participants' needs and thus achieve better results (Globe et al., 2014). This was also the case with the development of games in Pictogram Room. The balance activities in the program, as well as the other activities, are specifically designed to meet the needs of individuals with autism. Pictogram Room, like Wii Fit, provides a virtual representation of the participant on a screen. This helps the participants to get feedback on their movements by controlling and visualising their centre of pressure. Pictogram Room provides a simplistic centre of pressure control along a single axis (medial-lateral), which has also been used in the past with the Wii Fit, and was able to give the participants feedback on the balance tasks they performed, enabling them to successfully adjust their position and/or follow the instructions in the game (Clark et al., 2010).

Planning difficulties are well documented in the literature, as being prevalent in individuals with autism (Rinehart, 2006). In this study the children showed the greatest improvement in their planning skills. The design of Pictogram Room itself could explain this, as all the games required the completion of multiple steps. Activities that targeted both body awareness and balance skills consisted of a number of steps that needed to be followed. Some of these required a small number of movement combinations, for example moving the body up and down, but some others required multiple movements and more complicated actions, such as taking a step towards one side, raising one's hands and then moving, while being in the new position. Therefore, the children were working continuously on coordinating their bodies to perform a series of actions in every session. Having the chance to practice these skills in every session may have led to the greatest improvements being in this area. Therefore, these significant improvements in planning skills may be accounted for by the accumulated effects of a series of training steps which were structured, goal-directed, progressive and interrelated. For example, the children in the first few sessions completed activities that were more introductory, requiring simple motor planning. Once the simple games were completed, the activities became increasingly more complicated and physically demanding. This process is generally followed in SI therapy (Case-Smith and Bryan, 1999). For example, the occupational therapist can start with the child repetitively bending up and down, and then gradually introduce other body movements in-between, such as the game Heads, Shoulders, Knees and Toes that the child has to follow more steps.

Somatosensory control is an essential element of movement that leads to the correct coordination between limbs (Whitney and Wrisley, 2004). This means that working on other sensory-motor aspects can lead to improvement with planning skills. This is further supported by studies in individuals with Down Syndrome and cerebral palsy, as well as elderly people, in whom an overall improved sensory input led to an improvement in motor planning and sequencing (Humphries, Wright, Snider and McDougall, 1992; Wuang et al., 2011). In this study both body awareness and balance were significantly improved and this may have led to the improvement of planning skills too. Body awareness relates to the proprioceptive system, and balance relates to the vestibular. The processing in these two systems affects the execution of motor planning skills (Siaperas, 2012), so this may explain the fact that improvements here led to greater improvements in planning for the intervention group.

7.5 Social Play

Teachers reported that, after using Pictogram Room, they saw an improvement in social play skills in the intervention group. Therefore, the researcher added that as an emerged research question. One of the purposes of the study, therefore, was to investigate whether social play improved more in the children from the intervention group, than in the control group. Social play comprised four different aspects, which were: group play, parallel play, solitary play and neutral/ unoccupied, based on the work of Homes and Willoughby (2005) and Macintosh and Dissanayake (2006). The next sections discuss the results on social play overall, and in three different environments (i.e. PE, Playground and Classroom).

7.5.1 Overall Social Play

After working with Pictogram Room, the participants of the intervention group did not present a statistically significant improvement in their social play. However, they did present a practically significant improvement, compared to the control group. Data revealed that the frequency and duration of participation in group activities increased. Particularly evident was the duration of participation in group activities, where the difference between the intervention and the control group had a Cohen's d effect size of 1.28, suggesting the increased time of social play for the intervention group in group play. It was also evident that the intervention group engaged much less in solitary activities compared to the control group. This was observed in the frequency, and particularly, in the duration of solitary play, as the control group presented solitary play for a much longer period of time. The frequency of parallel play was about the same for the two groups, but the duration was significantly different (Cohen's d=0.87). Finally, the two groups were very similar in terms of the frequency and duration of being unoccupied.

These findings raise the possibility that difficulties in social play in children with autism could originate from difficulties in their sensory integration system, and, therefore, their sensory-motor problems. A number of studies have proposed that interventions based on sensory integration can lead to improvements in social skills (e.g. Bagatell al., 2006; Bass et al., 2009). The results of this study support the underlying assumption of sensory integration theory, that when children can modulate and regulate sensory information, they can be more available to engage and participate more in social activities (Ayres, 1972, 1979). As children with autism can have difficulties forming a clear awareness of their own body, they might not get adequate information from the proprioceptive and vestibular system (Bogdashina, 2003). If it is difficult for them to feel what their own body is doing, then this might make it very difficult for these children to interact with their environment and with others. Again, this can impact on their whole learning experience, development and social play skills.

In previous studies, researchers have shown that behaviours, such as stereotypic motor movements, hyper-activity and self-injurious behaviours have been correlated with sensory processing difficulties (Case-Smith and Bryan, 1999; Linderman and Stewart, 1999; Dawson and Watling, 2000; Watling and Dietz, 2007). Other studies have also shown that sensory-based interventions, especially SI therapy, can lead to a decrease in behavioural problems in children with autism, such as sensory processing difficulties (Fazlioglu and Baran, 2008), anxiety (Piravej et al, 2009), social skills difficulties (Bass et al., 2009) and self-stimulatory behaviours (Fertel-Daly et al, 2001). These problems can have considerable implications in the social, personal and educational domains and limit an individual's ability to participate effectively in everyday life routines (Smith et al, 2005). In the present study, the intervention with Pictogram Room has improved children's sensory-motor processing and, therefore, may have led to improvements in social play.

Besides the correlation between sensory processing and social skills, the improvement in social play of the participants in the intervention group may also be explained by neurochemistry and physical activity. Physical activity was a large part of Pictogram Room, as the games required children to move positions, jump etc. Neurochemical investigations have found abnormal levels of neurotransmitters, especially oxytocin and serotonin in autistic individuals and these neurotransmitters are related with social functioning (Kirsch and Meyer-Lindenberg, 2010). Oxytocin has been documented to be relevant for the modulation of complex emotional and social behaviour (Donaldson and Young, 2008), social attachment (Insel and Young, 2001), social exploration, recognition (Winslow and Insel, 2004), and trust (Kosfeld, Heinrichs, Zak, Fischbacher and Fehr, 2005). Further investigations have found that plasma oxytocin level is lower in autistic individuals and is negatively correlated with intellectual, adaptive, and social functioning (Quattrocki and Friston, 2014; Green et al., 2001; Modahl et al., 1998). Additionally, researchers have found inefficient metabolism of serotonin in different brain regions of individuals with autism (Chandana et al., 2005). The results of a number of studies indicate that physical exercise improves synthesis and metabolism of oxytocin (Hew-Butler, Noakes, Soldin, and Verbalis, 2008) and serotonin (Young, 2007). Although no neurochemical and physiological data was collected for the purposes of the present study, it can be speculated that 18 weeks of working with Pictogram Room may have improved the synthesis and metabolism of key brain neurotransmitters. However, whilst Pictogram Room offers opportunities for physical activity, it is not intense, unlike most studies conducted in increasing oxytocin and serotonin through physical activity, which have examined intense exercise (e.g. running) (Collins and Fitterling, 2009). Two studies were found that have been conducted on amount of exercise and serotonin changes and have shown results after 12 weeks of moderate exercise (Dunn et al., 2005). Additionally, oxytocin has been increased after four weeks of Yoga training in schizophrenic patients (Jayaram et al., 2013). However, both of these studies were in adults and were not specific to autism. Nonetheless, the physical element offered through Pictogram Room, along with the PE classes at the school, might account for improvements in the intervention group's social play behaviours.

7.5.2 Social Play across different environments

Besides the overall social play, the researcher measured social play separately in three different environments (PE, Classroom and Playground). In the PE environment the frequency of group play was neither statistically nor practically significantly different between the two groups. However, whilst not statistically significantly different, the duration of participation in group play for the intervention group was practically significantly different with a large effect size (Cohen's d=1.14). In terms of the frequency of parallel play, this was greater for the control group, but the duration was very similar between the two. Solitary play was different, in both frequency and duration, for the two groups. The intervention group engaged in less solitary play compared with the control group. Finally, regarding neutral state the two groups were the same in their frequencies and also similar in the duration of being unoccupied.

In the Classroom environment both the frequencies and the duration of participating in group, parallel, solitary play and neutral state were very similar between the two groups. There were no statistically significant differences between them and the practical significance was small and only had a medium effect size in some cases. There was a medium effect size in the frequency of group play, with the intervention group participating more, and in the neutral state, with the control group engaging more in this. In terms of the duration, the effect size was medium for the parallel play, with the intervention group participating more. Finally, in the playground, there were no statistically significant differences between the two groups, either for the frequencies or for the duration. However, there were practically significant differences in social play. The frequency of parallel play had a medium to large effect size, with the intervention group engaging more. The solitary play had a large effect size, suggesting that the intervention group engaged less in this behaviour. This pattern was followed for the duration component too. Also, although no large differences were noted in the frequency of group play between the two groups, the intervention group participated for a longer period of time in group play.

After the intervention, the experimental group reduced the frequency and the amount of time spent on solitary activities and engaged more in parallel play. This is in line with other studies, suggesting that parallel and solitary play are the most common play behaviours among children with autism. For example Holmes and Willoughby (2005), stated that the most observed play behaviour was parallel play, followed by solitary. These findings were also similar to those of Lord (1984), who concluded that children with autism spend more time playing alone than typically developing children, when presented with the option of playing with other children. The findings were also consistent with Restall and Magill-Evans' (1994) conclusion, that preschool-level children with autism will prefer to play alone, even in familiar settings with well-known adults present. When the intervention group reduced their solitary play, only a small part of this was because they participated in group activities. Generally, children with autism find it hard to intuitively follow group rules and actively play with peers unless it is instructed by an adult, or is the type of activity taking place in a specific environment (Holmes and Willoughby, 2005). This was also clearly observed in this study, as the group play for the intervention group was much higher for the PE environment. In PE, children were participating in group games, as instructed by the PE teacher and, therefore, had a greater chance to be part of it. The duration of this participation was very different between the intervention group and the control group. This suggested that after their improvement in sensory-motor skills, the children might have found it easier or felt more confident to participate. In the Playground environment, the control group showed a greater improvement across social play compared to the control group. This was a finding that the researcher did not anticipate. Previous studies have shown that in unstructured environments, such as the playground, children with autism may find it harder to participate in social games, even after intervention (Holmes and Willoughby, 2005). However, there is a lack of clarity in the literature regarding which environments children with autism may present more social play behaviours in. Some studies suggest that highly structured environments elicit more social play (O' Reilly et al., 2005; Chiang, 2009) whilst others claim the opposite (Potter and Whittaker, 2001).

In terms of the unoccupied/neutral state, both groups presented similar behaviour across all environments. When compared to other types of play, it was the one in which participants engaged the least. However, previous studies have shown that children with autism engage in group play the least (Homes and Willoughby, 2005; Macintosh and Dissanayake, 2006). In their study, Homes and Willoughby (2005) reported that the unoccupied state occurred and lasted less than solitary play, whereas in the Macintosh and Dissanayake's (2006) study it was vice versa. This study's results agreed with those of Homes and Willoughby's study. One possible explanation may be that the researcher's study, along with that of Homes and Willoughby, took place at schools, whereas Macintosh and Dissanayake's took place in a clinic. When children are observed in their natural environment, especially in free play where they may be alongside peers, it is more likely that they will engage in play behaviour, even if it is solitary (Homes and Willoughby, 2005).

7.6 Children's adaptive behaviour

For this study, the VABS-II was used to measure the two groups' adaptive behaviour. The results showed significant differences between the intervention and the control group in the daily living skills, socialisation and motor domains. The Cohen's d effect sizes were large (i.e. >0.8) for all three domains. Although the daily living skills domain was significantly different for the two groups, its sub-domains were not. However, the effect size for personal and school community sub-domains were large, and for the academic sub-domain, were medium. In relation to the socialisation subdomains, coping skills were significantly different between the two groups, with a large effect size. Whilst interpersonal relationships, and play and leisure time did have large effect sizes, they were not statistically significantly different between the intervention and control groups. In terms of the motor sub-domains, the gross motor sub-domain was statistically significantly different between the two groups, with a large effect size, whereas fine motor skills sub-domain was not significantly different and showed a small effect size. No significant differences were found between the two groups after the intervention period for the communication domain or its sub-domains. The effect size at the baseline and after the intervention was the same for both groups, indicating small to medium effect for the domain. For the sub-domains, the effect size was close to zero, indicating small to no effect.

To a certain extent, these results reflect the results from previous studies that implemented sensory-motor based interventions for children with autism. For example, Silva, Ayres and Schalock (2008), used a Qigong Sensory Training (QST) method for children with autism, to see the impact on their adaptive behaviour. Twenty-six children between three and six years old participated, a very similar age group to the one the researcher used. After participating in the intervention, the children scored higher in VABS-II interview based test. The greatest improvements were noted in daily living skills, motor development and communication. In a more recent study, Ajzenman, Standeven and Shurtleff (2013) conducted a pilot study using a single group pre-post test design, involving a 12-week hippotherapy training for children with autism between five and 12 years old. Data was collected one week before and one week after completion of the intervention and the researchers saw significant changes in the overall adaptive behaviour composite score. More specifically, they found significant differences in children's communication domain and especially in the receptive sub-domain. They also found significant differences in the socialisation domain, particularly in the coping sub-domain. However, they did not find significant differences in the daily living skills or motor domains. Researchers found significant improvements in communication in both studies, especially in the receptive subdomain.

The researcher in this study expected to see significant changes in the receptive communication sub-domain. While working in Pictogram Room, children had to follow specific instructions in order to complete the activities. Therefore, the researcher expected that the children who received the intervention would have improved their receptive communication skills. However, the ability to follow instructions can fall under the daily living skills domain, specifically the school community sub-domain. In this, the intervention group showed significant improvements, unlike the control group. This difference between the studies may be explained by the difference in the VABS-II form. The researcher used the teacher form, whereas the other two studies used the parent form. In many cases, when using variations of assessments, specific skills might be explained differently and fall into different categories. This may further explain why the second study found no differences in the daily living skills domain. This may also be influenced by the age difference between the researchers' study and the hippotherapy intervention. In the hippotherapy study the mean age of 8.4 years old, beyond the norms of <6 years old. It is possible that, as a result of age, and despite problems with daily living skills, many of the participants were functioning close to the norms reported in the VABS-II.

In the motor portion of the VABS-II significant differences were found between the intervention group and the control group, specifically in the gross motor area. A large proportion of the sensory-motor behaviours investigated was related to the gross motor domain, and was targeted by the activities in Pictogram Room. The games that the intervention group played required a whole-body movement, but not fine manipulation of objects. This may further explain why there were no significant differences in the fine motor sub-domain.

The improvements in coping skills were significant in this study, within the socialisation domain. Conversely, interpersonal relationships and play and leisure sub-domains were not statistically significant. However, they did have very large practical significance and the effect sizes were very large. As also seen from the results in social play, group activities increased and solitary play reduced significantly in the intervention group. Improvements in the socialisation area may have resulted from an integrative connection between improved daily living skills and sensory-motor improvements. Previous studies have demonstrated these improvements in social skills and sensory-motor development (Leary and Hill, 1996). Therefore, besides the increase in participation, there is also an increase in the quality of social interactions. The opportunities for interaction within Pictogram Room might have led to this overall increase in the socialisation domain. This is because, within the software environment, participants had the opportunity to practice skills such as turn-taking, cooperation, social contact (e.g. smile, talk), expressing emotions and sharing. Thus, by improving all of these skills, children may have been offered more opportunities to engage in social activities because of increased self-motivation and increased encouragement from their teachers and parents.

This is further supported by a recent study on changes in children with autism's adaptive skills, following a summer treatment camp (Walker, Barry and Bader, 2010). In this study of 12 children aged three to seven years old, social adaptive skills were specifically targeted. The sub skills which were specifically targeted indicated a greater improvement. Thus, in Walker et al.'s study the skills that were targeted the most, also improved the most (Walker, Barry and Bader, 2010). The fact that the measured behaviours corresponded to what was targeted through the activities is in line with meaningful activity producing enhanced sensation (Watling and Dietz, 2007). This is one of the main components of sensory integration. In an individual who is lacking appropriate sensory integration, this process then leads to better adaptive responding, and in turn helps to develop that sensory integration. This will then lead to an increase in learning and appropriate behaviour. Pictogram Room seeks to expose children to different sensory experiences and improve sensory processing. Through this process, children may have learnt to better register and modulate sensations and to make more appropriate adaptive responses.

Finally, it is important to note that social play, not just adaptive skills, was measured outside of the context of the technology environment. This suggests that those skills were generalised. When skills targeted in an intervention have a broader applicability, then improvements can be transferred to different environments (Kamps et al. 2002; Rao et al. 2008). This may be why, in adaptive skills, communication did not appear to have significant results. This would be because the type of communication happening in the technology environment was only relevant to that particular context. For example, it was not relevant to the classroom context, unlike behaviours like jumping which can be applied to different settings.

7.7 Implications of the use of Pictogram Room for the school practice

Children with autism can often face challenges participating in play activities with their peers, communicating effectively, forming and maintaining friendships and adjusting to behavioural norms that meet the societies' expectations (AOTA, 2010). Furthermore, as investigated in this thesis, children with autism might face sensory-motor problems. These problems can make it challenging to engage effectively in every day school, home and community activities (Baranek, 2002). Occupational therapists are usually positioned to work with children with autism on these skills, so as to support them, enhance their ability to participate in daily living situations, and make them more competent with their sensory-motor performance and socio-behavioural performance (AOTA, 2010). However, as previously discussed, it can be difficult for schools to bring in occupational therapists and even if they do, their time with the children can be limited. This is due to funding but also resource issues, as specialised rooms and equipment are needed for the therapy. Therefore, it is very important for the teachers to be able to assist their students, even when there is a shortage of occupational therapists. The next two sections discuss, firstly, the importance of the implementation of Pictogram Room in the school and, secondly, how Pictogram Room can enable educators and occupational therapists to work together more effectively.

7.7.1 Pictogram Room implementation

For any new intervention for students with autism, the degree of ease of implementation, and the ways in which it can be used by teachers in educational settings is paramount and is something that is missing from the current literature (Tanner, Dixon and Verenikina, 2010). Therefore, the researcher tried to capture those aspects through the interviews with the teachers. In terms of the ease of implementation of Pictogram Room, teachers at the beginning of the study did not feel comfortable using it, and it was one of the main reasons the researcher implemented the intervention. This is consistent with other literature, which reports that although technology has been proven to help in different areas of development for children with autism, teachers may find it intimidating (Tanner et al., 2010). They may find it hard to spend time to gather content and become familiar with new software and/or to develop teaching aids through it, given the lack of commercially available resources (More and Taylor, 2000; Stromer et al., 2006). For example, Coleman-Martin et al. (2005) concluded that teachers were not willing to create PowerPoint presentations because of limited knowledge of the programme and lack of time. However, by the end of the study, teachers had the chance to see the software and how children were working with it. They reported that after seeing the software they felt that it was easy to implement in the classroom and that it was not difficult to use the activities. As Susan mentioned in the interview:

> *'it is very easy to make it work. I'm not great with technology but it's pretty simple'*

Similarly, Jean said:

> *'I could have Pictogram Room in the classroom regularly. The kids would love it and it's so fun and easy to set up'.*

Therefore, if the study were to be conducted again, the researcher would give some time to the teachers to explore the software, make more demonstrations, and involve them in different steps of piloting the software, and not just present the activities. As Pritscher (2013) points out, when teachers are involved in all steps, from simple installation to more complex activities, they have the opportunity to familiarise themselves with new tools and become more confident in using them. Robinson and Sebba (2010) found that teachers who exhibited confidence in the classroom, combined with confidence and knowledge about digital technologies, were more likely to build the use of technologies into their teaching and were also more likely to employ a greater range of technologies. However, the studies addressing teacher competency in digital technologies and students with autism are few.

Teachers reported that in the future they could use Pictogram Room in the classroom with all children and adjust it according to individual needs. Most of the research to date has concentrated on the use of individualised technology programmes (Kinney, Vedora, and Stromer, 2003; Cramer et al., 2011). These researchers acknowledged that they did not know how a teacher could employ individual programmes in a classroom setting. It is important to implement technological assistance within the social-cultural contexts of an authentic educational setting, and assess whether it is useful in the learning environments. What is required is a learning environment that could maintain the level of teacher interaction, whilst incorporating digital technologies that teachers could readily implement in the applied setting. Pictogram Room was implemented in a school setting but individually with each student, without the rest being there. On one hand, this gave the opportunity to the researcher and the teachers to see that it can be used in the classroom, but it is important to see how it would be used in a group situation. This is mainly because the Kinect camera can detect anybody who is in its field view, and it can misinterpret another person as the user and 'miss' the individual who is actually using it. However, this can easily be solved either by manipulating a setting on the software that can re-detect the person using Pictogram Room, or by adjusting the way children are sitting to wait for their turn.

Teachers were asked about the use of Pictogram Room overall and made some very important suggestions and observations in their interviews. One of the suggestions was for the children to use Pictogram Room with their peers, instead of another adult. Evidence from studies mainly on children's social skills development suggest that peer-mediated or peer involvement interventions may hold a greater impact on the development of skills in children with autism. Chan et al. (2009) reviewed 42 studies that implemented peer mediated interventions for children with autism, 91% of them yielded positive results in various skill areas, such as academic and social skills. This strategy could also be used for Pictogram Room, as besides the development of sensory-motor skills, the use of the software by two peers could potentially lead to improvement in social interaction between them. Unfortunately, although teachers suggested implementing the software with peers, implementation and investigation within the study was not feasible, but would be of interest to investigate in the future.

Finally, although teachers suggested Pictogram Room to be used by two children, they also highlighted the importance of combining it with an adult and a child. They made reference to the potential of collaboration with occupational therapists to work on children's skills in the school with the software. One of the teachers mentioned that she showed Pictogram Room to the occupational therapist who came to the school, and reported that she found it exciting and was keen to use it. Therefore, this will be explored in section 7.7.2 where the researcher is discussing a collaborative model between teachers and occupational therapists with the use of Pictogram Room. Furthermore, as the findings were very positive for the children, teachers could potentially use Pictogram Room without necessarily having the input of an occupational therapist. However, it is important to have multidisciplinary teams for making decisions about the children, as these types of collaborations can lead to better outcomes (Barnett and O'Shaughnessy, 2015). This potential for collaboration between teachers and occupational therapists, regarding the use of Pictogram Room, is explored in the next section.

7.7.2 Potential for collaboration between teachers and occupational therapists

Occupational therapists' role and occupational therapy in educational settings have evolved along with general changes in education (AOTA, 2010). More recently, school administrators, teachers and occupational therapists are looking for models of working together that are relevant to the classroom environment and school curriculum (Barnett and O' Shaughnessy, 2015). Parents and school staff seek collaboration between each other and, with other clinicians, mutual decision making. This includes having students work together and be included as much as possible. However, the education training and placement of occupational therapists does not only cover educational settings, but also includes hospitals and nursing homes. This may make working in schools more difficult and time-limited. This was the case at the school where the researcher collected the data. The occupational therapist was splitting her time between different schools and hospitals, resulting in her only being able to come to the school six months after the school year had started. Even then, she was only able to do one ten-minute session a week. Moreover, the school did not have all the necessary equipment for this type of intervention.

School-based occupational therapy often can isolate students, requiring them to work separately from their peers in a different room (Case-Smith, 2002). Additionally, neither family nor teachers are encouraged to participate directly in the therapy. This was also the case in the school where the researcher carried out the study. That sometimes led to the students not working directly on skills which were relevant to the classroom environment or their actual needs. Also, the room was very small, preventing the other students from participating. Hence, the teachers expressed a need to have something working in the classroom that could include all students. They expressed the need for more opportunities for collaboration between themselves and the occupational therapist. They called for a universal access to equipment for all the students.

Research into occupational therapy suggests that a collaborative model is a key component for clinicians and could work well in school settings (Boshoff and Stewart, 2013). This statement was supported in the teachers' interviews too. This model suggests that rather than pulling students out of the classroom to work on different skills, school staff, together with occupational therapists, identify, assess, plan and apply interventions to best help the students. These interventions focus on the skills that the students need in the classroom and other school settings and, therefore, should be part of the daily curriculum. In that sense, the interventions students receive are effective, as they have the potential to improve their performance in the settings where they participate and learn (Kelly and Tincani, 2013).

As seen from the study's findings, Pictogram Room has the potential to help children with autism to improve their sensory-motor skills. Therefore, occupational therapists could work together with teachers, and possibly families, to adapt and/or modify the software according to the students' specific needs. This would help them to function better in the classroom, lunchroom, corridors, playground and all other school environments. Through structured and ongoing co-planning, occupational therapists and teachers can become familiar with each other's skills and classroom procedures (Friend and Cook, 2013). This would allow them to assess and decide on what areas they need to work on with each student. When defining the areas they can work on, such as body awareness, they could then pick out the activities from Pictogram Room that would work best and see how they could implement them.

They would decide together which skills a student needs to develop and these may be applicable to other students as well. Therefore, by using principles of the Universal Design Learning (Gargiulo, 2015), they could use the same activities of Pictogram Room, but personalise them to meet each student's needs. Pictogram Room can give this flexibility, as the activities can be universally applied to every learner, through easy options of personalisation. For example, after working with the teacher to identify the students' needs, the occupational therapist could show suggested activities from Pictogram Room that target those skills. The OT could then decide with the teacher which ones they could use and show the teacher how best to use them to work on the pre-decided skills. As the activities can follow the UDL principles, they could be used with many students with or without autism. In this way, inclusion and peer collaboration is also promoted. Furthermore, this allows the teacher to have more time with the students, not having to leave the classroom with the other children, but able to work with all of them at the same time. To sum up, Pictogram Room has the potential for teachers and occupational therapists in collaboration to promote students' sensory-motor skills in a very effective way.

7.8 Conducting experimental designs for intervention effectiveness in a school setting

While, there is a plethora of interventions available for the development of various skills in individuals with autism, there is a disconnection between educational research and practice (Parsons et al., 2013). The next sections discuss the existing gap that exists in that area, and how the researcher tried, to a certain extent, to address that through her study. Furthermore, she addresses issues when conducting experimental designs in a school setting, and the importance of the practitioners' involvement in these type of studies.

7.8.1 Research and practice gap for interventions in autism

The research-practice gap in autism is well documented in the literature (e.g. Dingfelder and Mandell, 2011; Parsons et al., 2013). It is a challenge for researchers to conduct intervention programmes in school settings, thus the majority of the studies testing effectiveness of interventions are still implemented in laboratory settings (Parsons and Kasari, 2013; Kossyvaki and Papoudi, 2016). However, when interventions are implemented in research settings they do not always translate in an effective way into school or community settings. Even if they were proven to be effective in a highly control environment as that of a lab, it does not necessarily mean that they are going to be effective when and if they are transferred to a school setting. This is evident from a large body of research showing that interventions for children with autism are not as effective in real world settings as they are in research settings, and do not have sustainable results over time (Storch and Crisp, 2004; Weisz et al., 2005). Therefore, it has been argued that testing an intervention directly in the children's natural environment, without first testing it in a lab setting, is more efficient (Weisz, 2000). This is because in real-world settings children have the chance to practice and apply the skills they learn in a place where those skills are relevant, such as their school. Therefore, it was very important for the researcher to implement the intervention in a school setting. Balance, Body Awareness and Planning skills that were the focus in this study, are skills that are relevant to children's everyday life (Parham et al., 2007) and, thus, it is important to develop those and apply them in different school contexts.

Additionally, the researcher, along with input from the teachers, chose activities from Pictogram Room that were relevant to the skills targeted, and tailored to the children's needs. This was crucial as in the past more attention was given on how to implement an intervention and its dosage (e.g. how many times or how many hours per week), than what was actually taught (Kasari, 2002). This resulted in many of these interventions showing mixed results regarding their efficacy (Kasari and Smith, 2016). This is also supported in the review by Case-Smith et al. (2014). They report that although SIB approaches are implemented in schools, for the development of sensory-motor skills in children with autism, the results from these studies are not promising. However, they also highlight that the lack of positive results was, in most of these cases, due to poor implementation of the approaches, as they usually were not relevant to children's skills and needs.

Longer term outcomes of interventions implemented for individuals with autism in different areas, including education, life skills and relationships, remain poor (Wittemeyer et al., 2011). This is a very important aspect, as many studies show immediate results after an intervention, but only a few conduct follow-up studies. For a school this is especially important, as practitioners can expect to see better results in their students, and improved practices from their side. This is something that was lacking from the researcher's study. Unfortunately, due to time restrictions and lack of resources, the researcher could not conduct a follow-up study. However, this is an important aspect, as it gives teachers more tools to use with their students that are not only effective, but can be used for longer periods of time, and establish a new part in the everyday classroom curriculum.

Practitioners report difficulty accessing research because the evidence has not been produced or research syntheses are not available. Practitioners often perceive scientific evidence as not providing useful recommendations or not being specific to their situation, resulting in their feeling that this evidence cannot meaningfully guide decision making (Honig and Coburn, 2008). Research outputs need to be translated into language that practitioners can interpret with clear implications and recommendations for practice (Parsons et al., 2013). Practitioners implementing interventions for autism in real-world settings often rely on methodologies and techniques that are not supported by research findings (Stahmer et al., 2005). Sometimes, even when interventions that are proven to be effective are used, they might not be implemented the way they were designed (Stahmer et al., 2010). Most autism programmes used in schools or communities incorporate elements of different interventions, which, in most cases, have not been tested in combination for their effectiveness (Chasson et al., 2007). As a result, autism interventions implemented in real-world settings are not always found to lead to skills improvement (Chasson et al., 2007). It would be possible, however, to overcome this issue. Potentially, this could be done through close collaboration between practitioners and researchers, which is an aspect explored within the next sections.

7.8.2 Experiments in schools

In the last few years there has been an increase in experimental designs conducted in school settings (Reichow, 2008). Often, when researchers conduct studies to test an intervention in school settings, they may need to start with feasibility testing (e.g. single-subject design), and then proceed to testing the intervention in more highly controlled conditions. This was also the case for the researcher, as it was very hard to have access to a population that met the inclusion criteria of the study, i.e. to have an intervention and a control group at the same time. Besides it being difficult to find a control group from the beginning of this study, it was important for the researcher to implement a single-subject design approach, so as to have information within the Software environment compared to the other environments. This was because most intervention studies that have been conducted with the use of TEL have shown positive findings for the technology environment, but have not tested for the generalisation of the acquired skills in other contexts (Grynszpan et al., 2014). Although, the study revealed that the Software environment was the one in which the intervention group presented the greatest improvement in their sensory-motor skills, generalisation to other environments was reported as well. This was further supported when a control group was recruited.

Single-subject designs remain the most common method of testing the effectiveness of an intervention for school-age children with autism in educational settings (Machalicek et al., 2008). Group design studies have been increasingly used in educational settings in the past decade (Reichow, 2008), providing important information at a group level for the effectiveness of an intervention that can be tested against other interventions or other groups of participants (Kasari and Smith, 2016). However, as mentioned previously, it is not always easy in school environments to identify participants that meet the inclusion criteria of a study at the same time. This was evident from the current research, which took two years to complete because it was not easy to find participants who met the inclusion criteria. Kasari and Smith (2016) suggested that to achieve greater reliability and validity for a study testing the effectiveness of an intervention, it is important to have as similar participants as possible. This is in terms of participants' characteristics, as well as settings. This was one of the reasons why the researcher carried out a large number of assessments for sample characterisation. Additionally, it was not easy to work in another school with similar characteristics as the one in which the researcher conducted her study. Therefore, she had to try to recruit participants for the control group the following school year.

Although experimental designs conducted in school settings provide evidence for intervention effectiveness, there are still limitations in terms of the social validity. This study provides social validation, to a great extent, through the interviews that were conducted with the teachers. This is important, as social validation has been found to be one of the main reasons of the research-practice gap, and it is about what practitioners find acceptable in terms of intervention goals, strategies and outcomes (Callahan et al., 2008). Tanner, Dixon and Verenikina (2010) note that only a few research studies using TEL interventions in the classroom report on the social validity of these interventions. They stress that classroom teachers are rarely interviewed to ascertain whether they feel that the technology was useful or effective in increasing different skills in children. On the whole, studies that involve some social validity have used mostly structured questionnaires for teachers and/or parents to complete, in relation to the effectiveness of an intervention used in the research study (Tuedor, 2006; Lacava et al., 2007; Tanner et al., 2010).

Although social validity and the taking into account of teachers', parents' and other practitioners' views when conducting a study have been recognised as important aspects, there is still a debate as to whether by doing so researchers can have strong experimental designs. de Bruin (2015) makes a strong claim about the increased quality of experimental designs which involve the individuals taking part in an intervention, such as teachers, in what she calls an inclusive approach. According to this approach, participants actively engage with all the research processes in a participatory way by providing constant feedback. The most positive aspect of following an inclusive approach is that, besides testing for the efficacy of an intervention, the researchers can also test for its effectiveness. This overcomes many criticisms of the pure experimental designs, since it gives the chance for incorporating methodological variety and understanding of the context (Porter, 2014). The researcher in this study did not follow a participatory approach, as in that of an inclusive study, but she involved teachers in different stages of the study, strengthening its social validity. Practitioner involvement in a study, and its importance, is explored in the next section.

7.8.3 Involvement of practitioners for conducting research in schools

The challenges of implementing interventions in real-world classrooms have been identified in the literature, with a clear recognition that meaningful collaboration with, and involvement from, the practitioners is essential for their effectiveness (Parsons et al., 2013; de Bruin, 2015; Kossyvaki and Papoudi, 2016). In order to identify the needs and goals for students with autism, it is important to involve both families and practitioners in research, and work with them rather than on them (Pellicano Dinsmore and Charman, 2014). Collaboration and dialogue are considered key to this type of research, however, much still remains to be understood about how such involvement can be facilitated and applied in practice. Also, how the emerging outcomes can be meaningfully translated into knowledge for the real-world application. Practitioners and researchers might have different views on what is important and what is the best process to follow (Damschroder et al., 2009), therefore, it is important that there is a common partnership and that the two sides work together.

A number of researchers have tried to provide a framework for collaborative models between researchers and practitioners, to test the effectiveness of different interventions. For example, Nastasi et al. (2000) suggest their own model – the Participatory Intervention Model (PIM). The PIM comprises three phases and there is an expectation that collaboration between researchers and other stakeholders is essential for the focus, design and implementation of an intervention. At all phases, there is partnership, in terms of implementation, data collection and interpretation of outcomes, so that there is sharing of power and control. Additionally, Lim, Tay and Hedberg (2011) provide a framework specifically for TEL interventions in schools, emphasising the teachers' involvement; the Activity Theory. In similar fashion with other interventions, technology interventions in schools need to be supported by all stakeholders to ensure their 'survival' and sustainability (Tay et al., 2012). From the Activity Theory perspective, a new intervention is not used just to extend the skills of the individual but it is incorporated into the wider learning environment, with specific goals and purposes for the students and teachers overall. The framework includes five processes, which are: identifying the subject, object, tools, community and rules. From the researcher's study perspective, the researcher (subject) was actively involved in the decision regarding the activities in Pictogram Room (tools), which would help children's sensory-motor skills development (object), with input from the teachers. However, the concepts of community and rules were not very strong in this study. These two elements, like the PIM framework, require a very active involvement from the staff, across and throughout the process, so as to make a change to the learning environment. Unfortunately, the researcher did not have the opportunity to do that throughout the study as, to a certain degree, the study was controlled by strict timelines, which did not accommodate for the teachers' busy schedule.

Another very important aspect of teachers' involvement in research studies, is the data collection that can take place from their side (Wittemeyer, et al. 2011). In this study, the teachers completed assessments about the children in order to monitor their progress, however, they did not directly work with them with Pictogram Room. If they had been involved with the data collection using the software, it would have added numerous positive aspects to the study. First and foremost, it would have provided the opportunity to work with more schools and more classes at the same time, which would have increased the number of participants and made the study more rigorous. Also, the teachers would have been able to see whether they could incorporate Pictogram Room in the everyday class program, and what kind of adjustments they might need to make in order to do so. Although through the interviews the two teachers discussed their view on how to use Pictogram Room, and gave their insights on its implementation, they did not have the chance to do this first hand, but rather through the pilot phase and the video recordings. As seen in the study of Parsons et al. (2015), when teachers are involved in the data collection process they have greater chance to become more motivated and possibly even participate in research paper writing, It was school staff that used the technology with the students with autism, they then created digital stories to share their experiences with the community, and also were part of the paper writing. Unfortunately, during the researcher's study, the classroom teachers had very busy schedules, with many changes happening at the school, which meant that being the ones conducting the data collection was not feasible. It is worthwhile to note that the nature of the study did not allow this to happen, the children participating would also have to be identified with sensory-motor difficulties and not all children in the same classroom met the inclusion criteria. However, this could have been overcome by having different goals for the other students, and have the software available for the whole classroom with the teachers implementing it as part of the curriculum and the classroom activities. As Odom et al. (2005) point out, it is vital in special education research that different methods are used to answer different research questions, and that all of these methods are valuable science; in other words, it is not just the 'gold standard' of randomised-controlled trials that matter.

As discussed in the section of the research and practice gap above, interventions that are conducted in lab settings might not translate well in real-world contexts. This may also happen in cases where the interventions were designed for one-to-one implementation. The classroom environment requires the involvement of a group of children and, therefore, this cannot be done without input from the teachers. Teachers are the ones who can help modify an intervention that was either developed in a lab, or implement it on a one-to-one basis, to fit the classroom's needs (Kasari and Smith, 2016). Although the researcher conducted the study at a school setting, she was working with the children in a separate classroom. Therefore, teacher involvement is necessary to facilitate the transferral of Pictogram Room into the classroom with the other children, and in deciding what would be the best ways for it to be used there.

In addition to considerations of staff involvement, there are opportunities to involve children in the research process. In the current study the children were involved in the customisation of the activities by choosing the music and the colours of their liking, but due to the fact that they were minimally verbal, they did not engage in the research process more fully. However, a wealth of research highlights the benefits of involving children in the research processes and practices (Flutter and Ruddock, 2004; Pritscher, 2013). Various approaches and methodologies have been employed ranging from basic engagement and user testing (e.g. Druin and Fast, 2002) to much deeper involvement such as participatory and co-design approaches (Druin, 2011; Guldberg et al., 2010). This study, however, employed more simplistic forms of engagement, as it is important for verbal children with autism to have more chances to be involved in research processes, but in the case of non-verbal or minimally verbal children with autism, as in this case, it is extremely rare (Pritcher, 2013).

7.9 Summary

This chapter discussed the results of the study, which indicate that the intervention using Pictogram Room for the development of children's with autism sensory-motor skills is effective. This effectiveness might be for different reasons, including the relevance of the activities to the targeted skills, and the software design itself, which allows free body input and physical manipulation. Additionally, the generalisation of sensory-motor skills learnt in the software environment to other environments was discussed. All children in the intervention group transferred the learnt skills from within the Software to the other environments, especially in PE. However in the Playground the differences were not as significant. In other words, the greatest improvement was noticed in more structured and adult-directed environment. In addition, the researcher discussed that the reason why those skills may have transferred to other environments could be because the study was conducted in the children's natural environment and not in a lab setting. However, there are limitations, in that the sample size in this study was small, and the researcher could not control, to an absolute extent, for other interventions that might have been taking place at the same time. Improvements in the sensory-motor sub-domains was discussed, with planning skills being the sub-domain that was improved the most. As both body awareness and balance skills were improved and, given the link established between these two with planning, the latter might account for this improvement (Siaperas, 2012). Furthermore, activities in Pictogram Room included the completion of multiple steps to achieve the end goal, which gave the children of the intervention group the chance to practice planning skills the most.

In addition, the researcher looked at social play and adaptive behaviours, as a link was suggested in the teachers' interviews. In terms of social play, no statistical significance was noted between the results of the two groups. However, the practical significance was high, especially for the parallel play that was increased for the intervention group, and solitary play that was reduced for the intervention group. In terms of different environments, there were the most differences in PE and in Playground. Unlike sensory-motor development, social play was elicited in a more unstructured environment. Social play can be related to sensory-motor development, as when the children can have a better sense of their body in space they might find it easier to participate in more social play. Finally, this chapter discussed the results on children's adaptive behaviours. The differences between the intervention and the control group were significant for the areas of daily living skills, socialisation and motor domains, but not for the communication. It is suggested that this might be mainly because the domains that were different were directly targeted through Pictogram Room, but not so much the communication domain.

It was also very important for the researcher to see how Pictogram Room might be used by the teachers. Therefore, there was a discussion of the findings from the teachers' interviews on the ways in which it can be used in the classroom. They highlighted the feasibility of the software and that it can be used by an adult and a child, but also with two children. Furthermore, in their interviews teachers' made reference to the limited access to occupational therapy for their students, and how they would like to work more with these professionals. In addition, one of the teachers had mentioned that she showed Pictogram Room to the occupational therapist that was coming into the school and she was very excited to work with it. Therefore, there was also a discussion on how teachers work in collaboration with occupational therapists, to use Pictogram Room in the school, targeting children's sensory-motor skills. As the researcher conducted an experimental design in a school setting for testing the effectiveness of an intervention, she discussed this process. Moreover, she highlighted the gap that exists in research and practice, with the plethora of existing interventions that are not always easy for parents and teachers to choose from. In addition, many of the existing interventions are developed in labs and, therefore, are not directly applicable in a classroom setting. Hence, the study concludes by making reference on the importance of involving school staff and children when conducting research in schools, and/or when an existing intervention is transferred in a real-world setting.

The next Chapter presents the conclusions of the study and discusses its implications for practice and future research.

CHAPTER 8

CONCLUSIONS AND IMPLICATIONS

8.1 Introduction

This final chapter of the thesis brings together all the findings and provides a summary. Additionally, limitations are discussed, and implications for practice and further research are suggested. The chapter concludes with making a reference to how this work, and its findings, have been, and will be, disseminated. The summary of the findings is presented in a way that follows the order of the research questions. Therefore, it starts by presenting the findings from children's sensory-motor development overall, and in different environments, as well as findings on sensory-motor sub-domains. Next, there is a summary of the findings from teachers' interviews. Finally, summary of findings regarding social play and adaptive behaviours are presented.

8.2 Summary of the findings regarding children's overall sensory-motor skills development

According to the data obtained through BBAP and SPM, the children who received the intervention saw a considerable improvement in their sensory-motor skills. These results are promising and support the use of innovative motion-based technologies, like Pictogram Room, to effectively enhance sensory-motor skills in children with autism, an area that is a quite under-researched. One of the reasons for its effectiveness may be the fact that it is a software specifically developed for individuals with autism, and takes into account their sensory-motor needs. Additionally, the teachers provided input as to which activities to use with the children in the intervention group, so in a sense they were tailored to the children's individual needs. Previous studies in interventions that tackled sensory-motor skills in children with autism also support that. For example, SI therapy, that operates within this paradigm has been proven to be more effective, compared to evidence from studies using SIB approaches, that are not always tailored to children's individual needs (Case-Smith et al., 2014). Additionally, Pictogram Room activities require users to follow some specific steps, which are structured, goal-directed, and progressive. This allowed the children to constantly work on sensory-motor skills, moving from simple to more complicated activities, while having the chance to practice those skills. Finally, the use of the Kinect camera allowed the children to interact with a simulated game environment and to receive real-time augmented feedback of their body positioning and performance. Therefore, they received constant feedback on their body position and had the chance to self-correct in a safe environment. This is one of the main advantages of TEL in general that has previously been shown to offer numerous benefits for children with autism (Parsons and Mitchell, 2002; Virnes et al., 2015).

8.3 Summary of the findings regarding children's sensory-motor skills development across different environments

The video data revealed that the greatest differences in the intervention group's sensory-motor skills were found in the Software environment, followed by PE, Classroom, Home and Play when their data was analysed alone. When compared to the control group, the greatest differences were noted in the PE, and then in the Classroom, at Home and lastly in the Playground. Therefore, this study has shown that, to a certain extent, the intervention group's sensory-motor skills were generalised to other environments, outside the Software. Activities completed within the Software were more relevant to activities that children perform during PE. Therefore, children might have had more chances to present behaviours related to sensory-motor skills, such as jumping or balancing on one foot. These findings may also be explained by the level of structure of the school environments. Evidence from previous studies on stereotypical behaviours revealed that these behaviours reduced in more structured environment (e.g. Prupas and Reid, 2001).

8.4 Summary of the findings regarding the development of the different sensory-motor sub-domains

For this study, sensory-motor development comprised of three sub-domains, which were Balance and Motion, Body Awareness and Planning and Ideas (Parham et al., 2007). The data from the videos, as well as that from parents' and teachers' assessments, showed Planning and Ideas as the sub-domain with the most significant for the intervention group. The results were similar for Balance and Motion, and Body Awareness and, although they did not improve as significantly as Planning and Ideas, it was still significant between pre- and post-intervention. The Planning and Ideas sub-domain was largely targeted through working with Pictogram Room. This is because, most activities required the completion of specific steps to reach a goal and complete the given task. This is also similar to how activities are in PE. Finally, Somatosensory control is an essential element of movement that leads to the correct coordination between limbs (Whitney and Wrisley, 2004). This means that working on other sensory-motor aspects can potentially lead to improvement with planning skills. In this study, both body awareness and balance were significantly improved and this may have led to the improvement of planning skills too.

8.5 Summary of the findings from teachers' interviews

To a great extent, teachers' interviews supported the quantitative results in relation to the intervention group and also gave new insights to the study. This was done through the specific questions they were asked regarding the children's performance before and after the intervention. They were also asked what they thought about the study overall and what recommendations they would make. Firstly, teachers suggested using Pictogram Room with a peer instead of an adult. At the end of the study they tried it with some other students working together and they were fascinated by the results. This suggestion was in line with previous studies, that have used peers as instructors, and showed more positive results on children's behaviours, compared to an adult instructor (Chan et al., 2009). Additionally, they noted that they had seen differences in children's social play and adaptive behaviour after using Pictogram Room. Bearing this in mind, the researcher decided to use VABS-II as a pre and post- intervention assessment to test children's adaptive behaviours, and created a new checklist on social play (i.e. SPA) to code the existing children's videos and the videos of the control group. Unfortunately, time and resources did not allow a study to be carried out using a peer as the instructor, but it was definitely an invaluable suggestion for future work. Finally, they expressed their interest to use Pictogram Room in collaboration with occupational therapists, as they saw the potential it has on children's sensory-motor skills.

8.6 Summary of findings for social play

Social play was divided into four subgroups, consisting of group, parallel and solitary play and finally, neutral state, in which the child does not engage in any form of play or interaction (Homes and Willoughby, 2005; Macintosh and Dissanayke, 2006). It was measured across three environments (i.e. PE, Classroom, Playground) using video data. The researcher measured both frequencies and duration of social play for the intervention and the control group. Firstly, there is a reference to the overall social play across all three environments, and then in each environment separately.

8.6.1 Overall social play

The video data across all environments did not reveal statistically significant differences between the intervention and the control group in their frequency of social play. After calculating the Cohen's d effect sizes, to see the practical significance, a medium effect was noted for group play, with the intervention group scoring higher than the control group. The effect size also revealed reduced solitary play for the intervention group (Cohen's d=0.72).

Regarding the duration of social play, again, there were no statistically significant differences between the intervention and the control group. However, when calculating Cohen's d effect sizes there were noticeable differences between the two groups. The intervention group significantly increased the time that they participated in group play, as well as parallel play, compared to the control group. The intervention group also decreased the time that they engaged in solitary play, compared to the control group.

8.6.2 Social play across different environments

None of the environments showed significant differences between the two groups in relation to the frequency of children's social play. When calculating the effect sizes during PE, a large practical significance in the intervention group's parallel play was noted, compared to the control group, and a medium effect for solitary play, as it was reduced more in the intervention group. In the Classroom setting group play had a medium effect size, with the intervention group participating to a greater extent, neutral state was also reduced for the intervention group. In the Playground the intervention group presented more parallel play behaviours, compared to the control group (Cohen's d=0.63).

With regards to the duration of social play in these three environments, again no statistical significance was observed between the two groups after the implementation of the intervention. When Cohen's d effect sizes were used in PE, group play for the intervention group then had a large practical significance (Cohen's d=1.14). In the Playground environment it was a medium effect and in the classroom environment group play duration was small. Parallel play duration was more practically significant for the intervention group in the Playground, and a medium effect size was noted in the Classroom environment. Although solitary play was about the same for the two groups in the Classroom environment, in PE and Playground a large effect size was noted, with the duration of solitary play for the intervention group significantly reduced. Finally, no large differences were noted between the effect sizes of the two groups for the neutral state.

8.7 Summary of findings for adaptive behaviour

After the intervention, the two groups presented significant differences in their adaptive behaviour, whereas at baseline they scored very similarly. The two groups were significantly different, both statistically and practically, in three of the four adaptive behaviour domains. The intervention group scored much higher in the Daily living skills, Socialisation and Motor domains, but was very similar to the control group for the Communication domain. Regarding the Daily living skills subdomains, there were no statistically significant differences between the control and the intervention group. However, Cohen's d effect sizes were medium for the academic subdomain, and large for personal and school community subdomains. In the Socialisation subdomains only coping skills were statistically significantly improved for the intervention group. However, Cohen's d effect sizes were large for all socialisation subdomains. Finally, from the Motor subdomains, gross motor subdomain was significantly different, both statistically and practically, for the two groups. The fine motor subdomain was very similar.

8.8 Contribution of the study to the field

This study attempted to cover research gaps on sensory-motor skills development in children with autism. As highlighted in the literature, there are a few evidence-based interventions that focus on the development of the sensory-motor skills of children with autism. The ones that exist, for example SI therapy, are usually implemented in clinics and/or require specialist equipment and personnel. In recent years, technology has advanced and has provided tools for teachers, parents and clinicians to use with the children, without having to always wait for a specialised professional to work with them (e.g. an occupational therapy). Through this study, the researcher attempted to provide such a tool to the teachers, one that could potentially be effective in developing their students' sensory-motor skills. However, it is important to note that this tool would be in addition to the work of a specialised professional, not a replacement. The technology the researcher used was Pictogram Room, an open access Kinect-based technology to teach children with autism a number of different skills. It is crucial to note that a number of researchers implement different strategies or interventions without having much input from the practitioners that work directly with the children (McAteer and Wilkinson, 2009; Ingersoll et al., 2005; Hwang and Hughes, 2000). Others conduct interviews or observations with practitioners to ascertain their views, or to see what they do in practice (Potter and Whittaker, 2001). Many times researchers and practitioners have different priorities and may interpret the implications for better practice in a different way (Zeuli, 1994) and that may not lead to the desired outcomes for the children.

In the current study, the researcher involved staff and engaged them in the selection of the activities in Pictogram Room, to choose activities that would better fit the students' needs. Giving the teachers the opportunity to be involved in the study process was not simply beneficial for the researcher, but on a greater level for the children and the teachers themselves. Susan, in her interview, said:

> *'I really enjoyed our work together. We decided what is best for our students as a team and it was an amazing experience. Now we have a*

tool that we can use all the time'.

Establishing a good relationship between the participants and the researchers is a great challenge in real world research. Often researchers place too many demands on teachers and sometimes ask for more data without it really being necessary. Taking into account teachers' time is extremely important, as it is not always easy for them to have a 'stranger' in their classroom, especially one who asks them to invest more time without justification. The researcher for this study tried to make this experience as positive as possible and, therefore, she volunteered to work at the school not only for the period of data collection, but for the whole school year.

Furthermore, although sensory-motor skills development in children with autism has been previously researched, it was not done extensively and, therefore, there are still many gaps to fill. Case-Smith et al. (2014) suggest that more rigorous research needs to be conducted on sensory-motor skillsets in order to test the efficacy of different interventions targeting this area. Also, many of the studies conducted so far took place in clinics or laboratories. Therefore, there is a greater need for more research in real world settings, such as homes and classrooms (Baranek, 2002). This is because effects found in one type of setting often do not translate to the other (Case-Smith et al., 2014; Kingstone et al., 2003).

This study provides an evaluation of using a new tool and recommendations for how it would be beneficial to use to improve certain skills in a school setting. A tool that is inexpensive, engaging and fun. It also contributed to the understanding of the importance of sensory-motor skills for children's development, and how these skills may affect other behaviours, such as social play and adaptive behaviours. Additionally, ecologically valid data and findings were produced from this study, which can potentially be transferred for use with other children, classes, settings and schools. Finally, it is a tool that could potentially assist occupational therapists with some of their work in school settings. As mentioned previously, schools can often have limited funding to bring in occupational therapists to work with the children on a regular basis. To add to that, schools do not always have the necessary space or equipment that is required for occupational therapy. Therefore, teachers and occupational therapists could work together to identify the type of activities and methods that would lead to greater improvements in children's skills. For example, the occupational therapist could spend time with the teacher discussing each student's needs. Resulting in a schedule of activities that teachers could use with the students in the classroom, when the occupational therapist is not at the school.

8.9 Limitations of the study

There are a number of limitations for this study that are mostly related to its design. Firstly, the sample size was small and, therefore, it is hard to draw conclusions for the general population of children with autism. Additionally, as the researcher had homogenous groups participating in the study, it is not certain that this intervention would work with different age groups, or with children with a different level of cognitive ability. However, the aim of this study was to introduce something new and alternative to some aspects of sensory-motor intervention, therefore, the nature of this study was quite exploratory. As a method to overcome some generalisability limitations, the researcher proceeded to recruit of a wait-list control group. This revealed some differences from the single-subject design that had been followed in order to purely analyse the data from the intervention group. However, even after recruiting the control group, the children's skills in the intervention group had improved further.

Although control groups can provide more reliable and valid data, a bigger sample size is necessary. Besides this, the ideal research design to establish causality and generalisability is the Randomised Controlled Trial (RCT) (Cohen et al., 2011). In a RCT participants are randomly allocated to either the intervention or the control group. Therefore, it is more rigorously proven whether any noted changes are due to the intervention or other uncontrolled factors (e.g. when other interventions are taking place at the same time). However, RCT could not happen for this study as the researcher had limited resources and could not find enough participants who matched the criteria and randomly allocate them in the two groups. Nonetheless, RCT is a design that the researcher would like to consider for future studies. Finally, due to time restrictions, the researcher did not have the chance to collect follow-up results. This was because the intervention period ended towards the end of the school year and many of the participants were moving to another school. It would be of the researcher's interest to collect longitudinal data and see long-term effects of the intervention.

8.10 Reflections on the research process

While writing up the thesis, the researcher started reflecting on the whole research process. This reflection led her to think about things that she would do differently if she had the chance to repeat the study. The main thing was the overall research design, as well as the implementation of the intervention. More specifically, the researcher would undertake a prolonged pilot study with more children. The insights teachers provided after the end of the data collection of the intervention group were invaluable and informed the researcher's study to a great extent. Had this input been available during the pilot testing, she would have implemented the intervention with three different groups; two intervention groups and a control group. One intervention group would use Pictogram Room with an adult, as in the current study, and the second intervention group would use Pictogram Room with a peer. Besides offering more opportunities for social interaction between peers, it would be valuable for the teachers to know if the intervention could yield more positive results across different skills areas. This change, therefore, would not only make the research design more rigorous, but would also provide information to the teachers that would help them improve their practice. Finally, as the school in which the researcher conducted her study was a mainstream school, the ultimate goal would be for the children with autism to be involved and interact with their typically developing peers. Hence, inclusion could be promoted by having two children working together.

8.11 Implications for further research and practice

There are several ways of conducting further research in order to inform practice of the impact of Pictogram Room on children's sensory-motor skills. Further research could use a more rigorous design, such as RCT, as well as be conducted with a larger number of participants. Another interesting aspect would be for researchers to use Pictogram Room with different age groups and different level of abilities. The researcher had contact with a school in the UK who used it with low functioning children with autism, and they reported that the children were engaged and managed to complete simple activities. Therefore, it would be interesting for this to be further investigated. It would also be fascinating to use it in different types of schools such as special schools. An environment in which children experienced different needs and the teachers faced different issues than those in mainstream school would be worth further exploration. As noted previously, it would be nice if children were using Pictogram Room with another peer. This peer could be either a typically developing child or a child with special needs. That would bring greater potential on peer collaboration, interaction and potentially inclusion. Furthermore, Pictogram Room could be tried beyond the school environment. As it is free software, it can be downloaded and used by parents with their children and/or siblings at home, friends and other peers beyond the school environments. Additionally, places such as fitness clubs may offer other environments and populations to explore. In addition to these potential areas of further research, other aspects of the study itself could be explored. Due to time restrictions, the researcher did not investigate all areas of the study. For example, future studies could seek teachers' views on the discrepancies between the numerical assessments and the interviews. Also, one of the most powerful elements of this study was the involvement of the teaching staff in the process, and the resulting good relationship between them and the researcher. If teachers are praised for the work, if their input is given value and their time is respected, then it is more likely that they will engage with and actively participate in the process. These are the people who know the students best and they can provide invaluable information for the research. It would also be interesting to compare different technologies, for example Wii-based, to see which one might work better for these skills. Also, motion-based activities could become a greater part of children's education. Besides being fun and engaging they can elicit many more positive skills. Children become more aware of their body and, therefore, can feel more confident in participating in more activities. As this study revealed, this results in increased social skills and adaptive behaviours. Furthermore, this study provided information on school based research and highlighted the importance of conducting research in children's natural environments. Although the researcher is aware of the challenges of conducting school-based research, it is of great importance, as research can be incorporated into children's every day programmes and lead to the targeted behaviours to be generalised to a greater extent. Finally, Pictogram Room could also be used as an assessment tool. For example, there are different types of activities including collaborative, competitive and turn-taking, and someone could test whether particular activities are more related to the development of certain skills. If the teachers have this information, they could also design activities outside the software, so as to support their students further.

8.12 Dissemination

There are different ways this research has been, and will continue to be, disseminated. Two journal papers are being prepared at the moment. The first is about the impact of Pictogram Room on children's sensory-motor development, and the second is on the impact it had on children's adaptive behaviour. Aspects of this research have also been presented at conferences and in other settings. The conferences at which this research has been presented are as follows:

- 12th Annual School of Education Research Conference (Birmingham/UK, 2013 – The poster presented won the first prize).
- STORIES conference (Oxford/UK, 2014)
- ITASD conference (Paris/France, 2014)

The research was also presented to other PhD students, as part of a workshop at the School of Education, University of Birmingham. Additionally, the researcher was invited to deliver a lecture, based on her research, to the Masters Program of Special Education, at the Department of Special Education, University of Thessaly, Volos, Greece in 2013. In 2015 this research was presented at the Technology and Innovation Lab, Child Study Center, Yale University, USA.

Furthermore, different schools have expressed their interest in using Pictogram Room for the students' sensory-motor development. These schools are in a variety of locations. There are two schools in West Midlands, UK, two schools in Athens, Greece, one school in Argentina, Latin America, one school in Boston, USA and two schools in Connecticut, USA. Finally, in terms of ongoing research there is a PhD researcher in Argentina who has expressed an interest to work with Pictogram Room and a Master's student in Paris, France who is pursuing research on Pictogram Room as part of his dissertation.

Additionally, this work was recently accepted as a poster presentation entitled: ‘’The Use of a Kinect-Based Technology to Enhance Sensory-Motor Skills in Children with Autism" at the 2016 International Meeting for Autism Research, in Baltimore in the USA. Furthermore, the researcher is going to use Pictogram Room as an assessment tool for sensory-motor skills and joint attention in primary school-aged children, at the Technology and Innovation Lab, Yale University. Finally, the researcher is going to use Pictogram Room as both an assessment and an intervention tool at a gym specifically designed for individuals with autism, in New Haven, Connecticut, USA.

8.13 Summary

This chapter presented an overview of the key findings of this study. It showed that using Pictogram Room is an effective way of increasing children’s sensory-motor skills. In terms of the environments, it showed that this improvement was greater in the more structured and activity-related environments (e.g. PE), which were more suitable for the presentation of the sensory-motor skills improvement. Also shown was that the Planning and Ideas subdomain showed the biggest improvement. Finally, there were improvements on children’s adaptive behaviour and social play, although in social play the difference was not statistically significant. The chapter also discussed the research gaps that the current study attempted to cover, the limitations of the study, proposals for future research and practice and finally, ways in which the PhD work has been, and will be, disseminated.

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APPENDICES

Appendix 3

Balance, Body Awareness and Planning (BBAP) Checklist

Setting (Software, PE, Classroom, Playground, Home): ____________________ Participant's code: ______________

Coder's name and relationship with the participant (e.g. teacher, parent, guardian, etc.): ____

<u>**Instructions**</u>**: 0=N/A** The child **did not have the opportunity** to present the behaviour in question in the specific videoed context. **1=** The child **consistently** demonstrated the behaviour in question consistently in the specific videoed context. **2=** The child **inconsistently** demonstrated the behaviour in question in the specific videoed context. **3=** The child **did not** present the behaviour in question in the **specific** videoed context.

	Pre-intervention						**Middle**	**Post-intervention**					
A. Balance							**No Coding**						
1. Leans on walls, furniture or people when standing													
2. Has poor coordination; appears clumsy													
3. Walks around room bumping into people and/or objects													
4. Jumps without keeping two feet together on takeoff and landing													
5. Difficulty to hop or stand on one foot													
6. Does not move body in time with music or people													
7. Says or seems easily to be tired/lethargic													
8. Turns whole body to look at something													
B. Body Awareness													
1. Needs to be in constant movement													
2. Seem unsure of how far to raise or lower body													
3.Moves stiffly													
4. Locks joints for stability													
5. Does not adjust position of feet as necessary													
C. Planning													
1. Has difficulty imitating demonstrated actions, such as movement games													
2. Difficulty to follow multiple steps to complete a task													
3. Fails to complete steps for the given task													

Appendix 4
Balance, Body Awareness and Planning (BBAP) Checklist: Definitions and Clarifications

A. Balance

1. Leans on walls, furniture or people when standing: When the child is just in a standing position, taking a break from an activity or waiting for his/her turn.

2. Has poor coordination; appears clumsy: The child finds it hard to control (complex) movement (e.g. using hand and leg at the same time) and becomes unstable.

3. Walks around room bumping into people and/or objects: The child bumps on objects or people while walking, running, etc.

4. Jumps without keeping two feet together on takeoff and landing: The child uses on foot at a time and/or keeps feet apart.

5. Difficulty to hop or stand on one foot: The foot does not leave the ground completely or the child is able to stand on one foot for just a couple of seconds.

6. Does not move body in time with music or people: In activities that is required to follow music or the movement of people, the child does not comply with the rhythm and/or finds it difficult to imitate moves.

7. Says or seems easily to be tired/lethargic: The child seems passive and does not respond to the activity and/or goes to sit down and/or says he/she is tired.

8. Turns whole body to look at something: In situations where the child could just turn his head and/or look at something using his/her eye gaze, he turns his body (e.g. shoulder, core, legs).

B. Body Awareness

1. Needs to be in constant movement: After directions of keep still and/or when the activity requires little or no movement the child continues to move (excessively).

2. Seem unsure of how far to raise or lower body: In situations where the child needs to put his body in the right position to complete the task (e.g. to catch a ball).

3. Moves stiffly: Movement is very rigid, difficulty in flexibility and bending.

4. Locks joints for stability: The child tightens the muscles to maintain balance, resulting in rigid and not fluent movement.

5. Does not adjust position of feet as necessary: Depending on task, the child does not perform the rights foot movement and/or gets confused.

C. Planning

1. Has difficulty imitating demonstrated actions, such as movement games: The child tries to imitate but fails to do so or does it incorrectly.

2. Difficulty to follow multiple steps to complete a task: The child understands and knows how to complete the task but finds it hard to follow/or forgets steps.

3. Fails to complete steps for the given task: The child does not understand and does not know how to perform the given task.