Bangor University

DOCTOR OF PHILOSOPHY

ABA-based interventions to increase social and mathematical skills in children with developmental disabilities in school settings

Tzanakaki, Pagona

Award date:
2012

Awarding institution:
Bangor University

Prifysgol Bangor

Bangor University

ABA-based interventions to increase social and mathematical skills in children with developmental disabilities in school settings

Pagona Tzanakaki

Thesis submitted to the School of Psychology, Bangor University, in partial fulfilment for the degree of Doctor of Philosophy

October 2012

Acknowledgements

First of all I want to say "Thank You" to God, the Father of Jesus and my Father, for I would have never started or completed this project without Him. You are the God of new beginnings!

I was privileged to study under an amazing supervision team: Prof. Richard Hastings, Dr Carl Hughes and Dr Corinna Grindle. My deepest gratitude for your guidance, patience, encouragement, kindness and humour during the last four years.

Thank you to the Greek Ministry of Education for funding my studies.

Thank you to Susie Nash and all the other members of the IDDRG for their kindness and support.

Thank you to Kath Huxley, Maria Saville and all the staff members of the Westwood ABA class for helping me during my first steps with ABA.

Thanks to Jonathan Morgan, Glenda Powel and the staff of Ysgol Y Gogarth for the two lovely years in Llandudno. Also to Denise Foran, Maggie Hoerger and Evagelia Katseli for their support and for sharing their expertise with me.

Thanks to all the beautiful children who participated in the studies and their families; it has been a privilege working with you all!

Thank you to my mom, for her love, support and encouragement through it all.

Table of Contents

List of Tables and Figures

Chapter 1: Introduction: Education of children with autism

Summary

As a teacher of young children who was interested in learning how to work effectively with children with autism, my original aim when I planned the projects that would be included in the present thesis was to explore different areas of the education of these children within ABA-based school environments. I had the opportunity both to work and to conduct research in such a setting, described in this first chapter of the thesis. About halfway through my research however, after the completion of two empirical studies, the occurrence of certain changes of circumstances within the school setting meant that it would not be possible to continue conducting research there as previously planned. Consequently, I had to make adjustments to the original focus of my PhD research and plan studies that would be conducted in different school settings that serve children with intellectual disability as well as autism. As one of the first two studies (conducted in the ABA school setting) involved the adaptation and initial evaluation of a numeracy curriculum for children with autism, I decided to focus on the academic area of mathematics for the remaining projects of my PhD research.

Chapter 1 of the present thesis starts with a brief overview of autism spectrum disorders. The issue of the various interventions implemented with children with autism is discussed next, and the behavioural model of early intervention is described. The area of school-based education of children with autism is discussed in the next section, followed by a description of the ABA school setting where the first two empirical studies included in the present thesis were conducted. In the final part of Chapter 1 an overview of the structure of the present thesis, and a brief description of the studies presented in the following chapters are presented.

Just about 70 years ago the term “autism” (derived from the Greek word for “self”) was used for the first time by Leo Kanner (1943) to describe the unusual behaviours of a small group of children who preferred to be alone, did not show interest in other people and exhibited peculiar interests for certain objects. Since then, the defining characteristics and diagnostic criteria for Autism Spectrum Disorders (ASD) have been described in more detail within diagnostic manuals (DSM-IV, APA 2000; ICD-10, World Health Organisation, 1993). These characteristics include impairments in three major areas: (a) social interaction (e.g., failure to develop relationships with peers, lack of interest in shared activities, absence of eye-contact and other non-verbal social behaviours); (b) communication (e.g., lack or delayed development of spoken language, absence of non-verbal communicative behaviours such as gestures, lack of initiating to others even when the person can speak) and (c) the existence of unusual, restricted interests and stereotyped behaviours (e.g., preoccupation with certain parts of objects instead of functional engagement, persistence in routines and difficulties with transition and change, presence of repetitive, stereotyped movements such as rocking, hand-flapping, spinning objects, squinting, lining up items).

As the term “spectrum” implies, individual children who qualify for a diagnosis of ASD present quite diverse social, communicative, and behavioural profiles (Symon & Boettcher, 2008). For example, some children may be completely non-verbal or have some echolalic language. Others have some verbal skills, however the quantity and the quality of verbal interactions are limited. For example, a child may have the ability to ask for desired items but be unable to ask questions or initiate to other children (Koegel, 2000). A number of children exhibit disruptive behaviours such as tantrums, aggression and self-injury. Levels of cognitive development vary as well, with an estimated 50-70% of children having an intellectual disability while others have IQ scores that fall within the typical range (Lovaas, 2003; Matson & Shoemaker, 2009; Wing, 1993).

Interventions for Children with Autism

There are severe impairments connected with autism, considerable diversity of individual profiles, and the number of children who are being diagnosed with ASD worldwide is rising (Wilczynski & Christian, 2008). Therefore, there is an increasing interest in the disorder and a large amount of related research. It is likely that autism is a result of an atypical brain development. At this point in time, despite the progress in scientific areas such as genetics, brain imaging and immunology, the exact aetiology of ASD is still unknown and no evidence-based medical treatments that address the core causes of autism are available (Rapin & Tuchman, 2008).

When a child receives an ASD diagnosis, often his/her parents are faced with confusion regarding the next step they should take, and the choice of the most appropriate intervention. Numerous "treatments" have been developed that could be broadly grouped into the following categories: (a) standard therapies (e.g., speech and language therapy, music therapy), (b) skill-based interventions (e.g., ABA-based intervention, Social Stories), (c) diets and vitamin supplements (e.g., gluten and casein-free diets), (d) physiological treatments (e.g., sensory integration, auditory integration training), (e) alternative treatments (e.g. aromatherapy), (f) relationship-based treatments (e.g., gentle teaching, Son-rise), and (g) programs that combine elements of different treatments (Green et al., 2006). However many of these have not been evaluated using rigorous scientific methods and are based on anecdotal evidence only (Green, 1996). In many cases professionals who deliver the child's diagnosis do not offer recommendations on evidence-based interventions. Therefore, parents turn to other sources for relevant information, such as the internet or other parents of a child with autism (Maurice, Mannion, Letso, & Perry, 2001; Tzanakaki, Grindle, Hastings, & Hughes, 2012). Often more than one intervention is tried by parents. According to an internet survey conducted with 552 parents of children with autism, each family were using on average seven different treatments with their child at the time of the survey (Green et al., 2006). Results indicated that strong empirical evidence may not be the main criterion for choosing an intervention; parents reported using both evidence-based interventions and those lacking empirical evidence (Green et al., 2006).

The Behavioural Model of Intervention

An extensive amount of research including a number of systematic reviews and meta-analyses of the literature indicate that educational interventions based on the principles of Applied Behaviour Analysis (ABA) are the benchmark treatments for ASD (Eikeseth, 2009; Eldevik et al., 2009; Peters-Sheffer, Didden, Korzilius, & Sturmey, 2011; Reichow & Wolery, 2009; Reichow, 2012). Early Intensive Behavioural Intervention (EIBI) programs are individually designed to correspond to each child's needs. They encompass a wide range of skills including following instructions, verbal skills (e.g., requesting for desired items, labelling items/actions/persons, answering questions), imitating others' behaviour, self-help skills, play skills, pre- academic and academic skills. Intervention implementation preferably begins at an early age (under the age of 5). Teaching initially is conducted at the child's home on a one-to-one basis and is intensive (at least 20 hours per week). Program design and supervision are undertaken by experienced persons who have extensive training in ABA procedures. Detailed data are collected daily and decisions concerning the different areas of the program are guided by a continuous evaluation of the data (Eldevik et al., 2009; Leaf & McEachin, 1999; Lovaas, 2003; Maurice, Green, & Luce, 1996).

A wide range of techniques based on the principles of ABA are used within EIBI programs. Some of the most prominent are: (a) *The use of "rewards"* to reinforce desired behaviour, based on Skinner's principle of operant conditioning (i.e., the consequences following an instance of behaviour increase/decrease the probability of the behaviour occurring in the future). Items or activities preferred by the student are used as reinforcers. (b) *Task analysis* is used to break complicated skills into smaller, manageable steps. The student only needs to learn one step at a time. (c) The use and systematic fading of *prompts*. To teach new skills various types of prompts are often used by the teacher. Prompts range from quite extensive (e.g., manually guiding the student to perform the task) to least intrusive (e.g., a pointing gesture to indicate the correct answer). When the student can perform the task with the help of the prompt, the procedure of *prompt-fading* (i.e., the gradual removal of the prompt) is being implemented so that the student will eventually be able to perform the task independently. (d) *Generalisation* of acquired skills. Because children with ASD may not automatically transfer knowledge acquired in one environment to other environments, in EIBI programs systematic steps are programmed to ensure the child can perform a task using a variety of stimuli, with different persons presenting the instruction, and in different settings. (e) *Functional assessments* of problem behaviours are conducted to identify the purpose(s) these behaviours serve for the child. For example, a child may exhibit aggression because this has allowed them to escape a task, ensure attention from adults, or obtain a desired item. Identifying the function of the behaviour enables the instructors to design an appropriate intervention (e.g. teach the child more appropriate ways of asking for a termination of a task or a desired item, give him/her attention when the child is behaving appropriately) (Grindle, Hastings et al., 2009; Lovaas, 2003).

Perhaps the most widely used format of one-to-one teaching within ABA programs is discrete-trial-training (DTT) (Smith, 2001). A discrete trial is a small instructional unit that lasts a few seconds and consists of the following parts: (a) The teacher gives an instruction to the student; (b) the student responds (correctly or incorrectly); (c) the teacher gives a consequence depending on the student’s response: a reward (e.g., praise, a short interval of playing with a favourite toy) or an indication that the response was incorrect (e.g., an informative “no”); (d) a short inter-trial interval, a pause of 2-3 seconds before the next instruction is presented to the child. Often, immediately after the presentation of the instruction, the teacher may assist the student to respond correctly by giving him a prompt.

School Education of Children with Autism

When children with ASD enter the school system they may be enrolled either in general education classrooms or in classrooms serving students with special needs (whether within a mainstream school environment or a special school). Across both of these types of educational settings the most common model used seems to be an “eclectic” treatment that combines elements of various interventions. Eldevik, Hastings, Jahr and Hughes (2012) described such a model used in Norwegian pre-schools; interventions used included alternative communication (i.e., using pictures or symbols), sensory integration (i.e., activities such as stretching, rocking, going on a swing, massages and listening to music), a few ABA programs (i.e., matching, imitation), and elements of structured teaching (i.e., the use of picture schedules, specific areas designated for work activities, tasks to be completed placed in baskets). Hess, Morrier, Heflin and Ivey (2008) conducted a survey with teachers of pre-school to high-school aged children with ASD in the USA. Results revealed the use of a wide range of interventions with the five most common being gentle teaching (an interpersonal relationship based approach), sensory integration, cognitive behavioural modification, assistive technology and social stories. Hess et al. (2008) concluded that evidence of effectiveness was not the primary criterion of choosing an intervention, a finding similar to the results of the survey conducted with parents of children with ASD (Green et al., 2006). Another important implication of the Hess et al. (2008) survey was the lack of clear guidelines on best educational practices for children with ASD, meaning that teachers of these children might have to make their own decisions regarding the interventions they will use.

As EIBI intervention usually starts before the child has reached school age, the main body of relevant literature involves treatment conducted either at the children's family homes or at specialised clinics. A very small number of studies have evaluated EIBI interventions conducted at school settings. In the study by Eldevik et al. (2012) a comprehensive (i.e., aiming towards the child's overall development by targeting a wide range of areas) EIBI model was implemented in Norwegian regular education pre-school settings with children aged between 2 and 6 years. Each child received on average 13.6 hours of individualized intervention per week for approximately two years. Members of the pre-school staff who were trained and supervised by experienced behaviour analysts implemented the intervention. Pre- and post- intervention assessments using standardized measures indicated that the children made significant improvements on intellectual functioning (IQ) and adaptive behaviour performance. A second group of children with similar characteristics at intake who received treatment in pre-school settings that used the "eclectic" model of intervention (combination of elements of various approaches) did not make any gains at the end of the two-year period.

Another study reported the progress of six children with ASD aged between 3 and 6 years, who received intensive individualized intervention in an EIBI pre-school setting in Ireland (McGarrel, Healy, Leader, O'Connor, & Kenny, 2009). After 3 to 4 years of comprehensive intervention in this setting all six children made gains in IQ and adaptive behavioural scores. Additionally, during the course of the intervention the amount of time each child spent in individualised teaching was gradually decreased so that all 6 children were able to attend regular education elementary classrooms on leaving the ABA pre- school setting.

Two more studies conducted in Norway examined the effects of school-based comprehensive EIBI on a group of 4 to 7 year old children enrolled in regular education classrooms and compared their progress to a similar group o f children who received eclectic treatment (Eikeseth, Smith, Jahr, & Eldevik, 2002, 2007). Children in both groups received intervention for approximately 32 months. While attending pre-school the children (of both groups) received on average 28 hours of individualized teaching per week; upon entrance into elementary school individualized weekly intervention was reduced to approximately 17 hours. Results indicated that children of the EIBI group made larger gains on IQ and adaptive behaviour measures and exhibited less severe challenging behaviours than the children of the eclectic treatment group at post- treatment (Eikeseth et al., 2007).

Finally, another study (also conducted in Norway) experimented with a less intensive intervention in school settings. Children of both the behavioural and the eclectic treatment groups received 12 hours of intervention per week. Results were in favour of the behavioural group but gains were modest compared to those attained by more intensive programs (Eldevik, Eikeseth, Jahr, & Smith, 2006).

These findings, although still of a small scale, suggest that the ABA-based model of comprehensive intervention for children with ASD can be successfully implemented within school settings and that it may yield favourable results compared to the widely used eclectic model of education.

The Westwood School ABA Class

In the UK a very small number of students with ASD receive school instruction based on an ABA model. A recent census (Griffith, Fletcher, & Hastings, 2012) identified 14 ABA school settings, serving 258 students with ASD aged between 3 and 17 years. These included 10 ABA schools, two ABA classes within special school settings, and another two ABA classes within regular education school settings. One of the latter settings was situated in North Wales. The local educational authorities of two counties in collaboration with Bangor

University established an ABA class within a local primary school, Westwood School. The educational model is described in detail in two papers by Grindle et al. (2009; 2012); a brief description is provided here.

A university employed ABA consultant with a doctoral degree and a long experience in working with children with ASD was in charge of organizing the children's individualised teaching programs and the ongoing staff training in the class. The class served children whose age ranged between 3 years 6 months and 7 years old. To be enrolled in the ABA class a child had to have a diagnosis of autism, a statement of special educational needs and a recommendation for placement within an appropriately resourced class setting by their local educational authority. Upon enrolment in the ABA class each child's skill level was assessed using the ABLLS (Partington & Sundberg, 2006), an assessment tool that covers a wide range of skills (e.g., language, play skills, self-help, social skills, pre- academic and academic skills, motor skills). Based on the child's baseline performance, an individualised comprehensive curriculum (i.e., including targets from all these areas) based on widely used published manuals for children with ASD (e.g., Leaf & McEachin, 1999; Lovaas, 2003; Maurice et al., 1996; Partington & Sundberg, 2006) was designed by the consultant of the class. Initial targets often included mainly "learning to learn" skills, such as being able to sit on a chair and engage in an activity for a few seconds, following simple instructions and appropriately communicating basic needs. For the larger part of the school day the child worked on these targets on a one-to-one basis with ABA-trained therapists. DTT was the teaching format used during the individualized sessions. Typically during the day each child had sessions with two different therapists to ensure that skills would be generalized across different instructors. Each child had his/her own work area within the ABA class consisting of a table and chairs, drawers and shelves for teaching materials and favourite toys the child could engage with during short breaks between tasks. Interspersed throughout the day were small-group activities, such as assembly and singing/story time.

Integration of the children with ASD into the regular education classroom with typically developing peers was an important target of the ABA class. Therefore as soon as the child had acquired some basic skills he/she started spending daily some time in that setting (within the same school) supported by an ABA therapist. Individual targets in this area differed and were dependent on the child's ability to adjust to the regular education class environment and benefit from it (e.g., work on similar academic targets as typically developing peers, follow group instructions). Some of the children were able to gradually increase the time they spent in this environment to a few hours every day, and were thus prepared to be enrolled in more typical school settings upon leaving the ABA class.

Outcomes of the children who attended the ABA Westwood class were recently reported by Grindle et al. (2012). Standardized tests measuring intellectual functioning (IQ) (Leiter - R, Roid & Miller, 1997; or Stanford-Binet Intelligence Scale - 4th edition, Thorndike, Hagen, & Sattler, 1986), adaptive behaviours (VABS, Sparrow, Cicchetti, & Balla, 2005) and basic language and learning skills (ABLLS-R, Partington & Sundberg, 2006) were conducted with each child at three points: at the time of enrolment, after 1 year and after 2 years in the ABA class. Results indicated that at the end of their first year in the class the children made marginally significant improvements on IQ scores, and significant gains on adaptive behaviours and the different skill areas measured by the ABLLS-R. At the end of their second year the children had continued to increase their scores and made significant improvements on the VABS and the ABLLS-R while IQ gains were not statistically significant. Additionally, score changes on IQ and the VABS after two years in the ABA class were compared to those of a similar group of children who had received two years of eclectic school intervention. According to this analysis, the children enrolled in the

Westwood class made larger improvements in both areas. There was a significant between-groups difference on the VABS whereas the difference on the IQ scores was not significant (Grindle et al., 2012).

Structure of Thesis and Background to the Included Studies

I am a Greek pre-school teacher with a background in regular education. Within the Greek educational system children can be enrolled into pre-schools when they are 4 years old, up to the age of 6 when they enter elementary school. After about 10 years of working in regular education pre-schools I decided to explore the area of autism and took a one-year MA course on this subject in the UK. Learning about the deficits in the three major areas of communication, social interaction and restricted interests/ unusual behaviours was enlightening but at the same time resulted in a number of new questions regarding how best to teach young children who are diagnosed with ASD. According to almost every book I read on the subject, many of which had been written by parents of children with ASD living in the USA, ABA was recommended as an effective practice that helped the children start to learn and progress. During the time of the MA course however, I did not have the opportunity to observe ABA-based intervention used within the public schools I visited in the UK as the regular practice was the eclectic model described earlier in this chapter. The only contact I was able to have with ABA during that period was a brief visit to a London ABA school for children with ASD.

At the end of the MA course I decided that I needed to learn more about best teaching methodologies for children with autism before I was ready to return to Greece to work with these children. I found that Bangor University was one of the few UK universities that conducted research on ABA in the education of children with ASD and also had an MSc ABA course. I was enrolled in the university for a doctoral degree that would enable me attain the following goals: (a) gain understanding of the basic principles of ABA by completing relevant modules, (b) have the opportunity to gain practical experience by working in an ABA setting for children with autism, and (c) conduct research on different aspects of the education of children with autism using effective practices under the guidance of persons with a long experience in this field.

During the first two years of my doctoral degree I had the opportunity to work as an one-to-one therapist for children with autism in the ABA Westwood class, first on a voluntary basis and then as a part-time staff member. The collaborative management of the ABA class with the local educational authorities gave Bangor University personnel and research students the opportunity to conduct research in an environment that was organised and managed to a very high standard by Dr Grindle, one of my supervisors, together with a team of experienced staff. During the second year of this period the studies described in Chapters 2 and 4 of the present thesis were conducted.

These studies were a result of my research interest in exploring new approaches in different applied areas of ABA-based intervention for children with ASD. With the main body of literature being focused on comprehensive educational programs that target the child's global development and using outcome measures of intellectual functioning (IQ) and adaptive behaviours, other areas such as best methods to teach different curriculum domains to children with autism have received less attention. Information on how to teach reading or mathematics within ABA programs, for example, is limited. Similarly within existing ABA curriculum guides (Leaf & McEachin, 1999; Maurice et al., 1996; Partington & Sundberg, 2006) the sections devoted to specific academic areas are rather concise. My aim was to provide some new insights and evidence in various educational curriculum areas for children with autism, using behavioural intervention methods.

In Chapter 2 of the thesis an intervention aiming to increase social skills in children with autism by teaching them to initiate more often to their peers is described. The method explored involved the use of a tactile prompt, a small device like a pager that was placed in the child's pocket and was programmed to vibrate at regular intervals. The child was taught to verbally initiate to a peer when he felt the vibration. Two studies comprise this chapter, the first of which was conducted in the ABA Westwood class. The second study that aimed to replicate and extend the findings of the first was conducted during the following academic year in different school settings, under joint supervision of Dr Grindle and myself. Both studies found that the intervention was effective as the rate of the target children's initiations towards their peers increased. Additionally, in the second study, the use of the tactile prompt was successfully faded while the rate of initiations remained high.

The remaining three main chapters of the present thesis focus on a different curriculum area, that of mathematical interventions. An initial question explored in this part of the thesis involves mathematical interventions that have been used with children diagnosed with autism in published research. An exploratory search into the literature of interventions for children with autism revealed that a small number of studies have described mathematical interventions with these children. Some of these studies have been included in meta-analyses on teaching mathematics to students with intellectual disabilities (e.g., Browder, Spooner, Ahlgrim-Delzell, Harris, & Wakeman, 2008; Buttler, Miller, Lee, & Pierce, 2001). However no systematic reviews or meta-analyses that have focused specifically on children with autism were found. Therefore a systematic review of the literature was conducted, presented in Chapter 3 of this thesis.

An exploratory mathematical intervention with children with autism is described in Chapter 4 of the present thesis. Because of the small number of lessons and the lack of detailed guidance on teaching mathematics within ABA curriculum guides, the possibility of using a detailed numeracy curriculum that was initially designed for use with typically developing children who have mathematical difficulties was explored. The Maths Recovery curriculum was adapted for use with children with autism in ABA intervention programs. The adapted numeracy program was then used to teach all the children in the ABA Westwood class who had the necessary pre- requisite skills and whose numeracy skills fell below their age level (all but two of the children enrolled in the class at that point). Results from this practice-focused research evaluation indicated that all the children who participated in the study improved their numeracy skills.

The two research studies described in Chapters 2 and 4 were conducted during the last year of the collaboration between Bangor University and the local educational authorities for the management of the ABA class, with some of the same children whose progress was documented by Grindle et al. (2012). The fact that the university would not be involved any more in the management of the ABA class meant that university personnel and students would not be able to continue conducting research in this venue. Consequently, a revision of the focus of my PhD research became necessary at that point. Following the adaptation of the Maths Recovery curriculum described in Chapter 4, I decided that teaching mathematics to children with autism and other developmental disabilities was an area I would like to further explore. The small scale evaluation of the adapted Maths Recovery curriculum provided some initial evidence on the effectiveness of this numeracy program with children with developmental disabilities. To help us design further evaluation steps, the framework suggested by the Medical Research Council (MRC, 2008) on the development and evaluation of complex interventions was considered. According to the MRC guidelines recommended stages in this process include the identification/development of a theory, followed by a series of pilot studies that test different aspects of feasibility; the complex intervention is then evaluated, first at an exploratory and then at a more definite level, preferably using randomized controlled trial (RCT) studies. Finally the intervention can be disseminated into non-research environments.

In the pilot study described in Chapter 4 a number of elements of the implementation of Maths Recovery with children with ASD were tested; we found that within an ABA school environment the teaching manual and the procedures for staff training and supervision enabled the therapists to effectively implement the intervention; the DTT teaching format was compatible with the individualized teaching model of Maths Recover; finally, the outcome measures (especially TEMA-3) depicted the post-intervention progress of the children. A next possible stage could involve a study that would evaluate the program with a large number of participants, using a strong methodological design (such as an RCT study). An additional research question involved the possibility of implementing this intervention in a non-ABA school setting (e.g. a special needs school). Before a definitive RCT study could be conducted in such an environment the following additional elements needed to be tested for feasibility: (a) the willingness of parents to allow their children to be randomly allocated into an intervention and a control group; (b) the delivery of an individualised intervention within a less resourced school environment (i.e., a lower staff-to-students ratio, lack of staff expertise on ABA teaching methods); (c) the effort required for training and supervision of staff within that environment; and (d) the resources needed to teach a larger number of children. Conducting a pilot RCT study that would help us test these elements was therefore considered as a next appropriate step.

Dissemination of the positive results of the different university led ABA intervention projects for children with autism created an interest for the application of similar research projects among local special needs schools in North Wales. One of these schools, serving children with intellectual and developmental disabilities, invited research teams from Bangor University to cooperate with school personnel on the areas of managing challenging behaviours, early comprehensive intervention of young children with autism, and teaching of academics (reading and mathematics). The possibility of conducting an RCT study using the adapted Maths Recovery curriculum was discussed with the head teacher of the school; both he and the children's parents agreed that we could conduct a randomized controlled study with a waiting list control design, so that the children in the control group could also receive the intervention at a later point. This study is described in Chapter 5 of the present thesis. Results indicated that the adapted Maths Recovery curriculum was successfully implemented and resulted in increased numeracy scores for the children of the intervention group.

Finally, Chapter 6 of the present thesis contains a general discussion on the different themes arising from the previous chapters. Then the methodological limitations of the empirical studies are discussed as well as implications for future research. Also, I present some initial information on how the knowledge acquired during my doctoral studies can be applied in the context of the Greek educational system where I have started work in a special needs pre- school setting that serves children with intellectual and developmental disabilities.

Chapter 2. Use of a Tactile Prompt to Increase Social Initiations in Children with Autism[1]

[1] I want to thank the following persons who contributed to this empirical study and who will be at times referred to as co-authors of this chapter: Corinna Grindle, Sarah Dungait, Amy Hulson-Jones, Maria Saville, Carl Hughes and Richard Hastings.

Abstract

Making appropriate verbal initiations to others is an aspect of social interactions that seems to be especially problematic for individuals with autism. A variety of teaching and prompting methods have been developed to address the issue. A method that has been reported to be effective in the literature involves the use of a tactile prompt, a small device that can fit in the participant's pocket and can be programmed to vibrate at regular intervals. The aim of the current project was to extend the existing research on the use of the tactile prompt by incorporating reinforcement during intervention and attempting a systematic fading of the prompt. The project consists of two similar studies. Three children with autism participated in Study 1and two children in Study 2. In both studies the intervention was conducted during free-play activities with mainstream peers. Results indicated that the participants' verbal initiations to their peers increased in comparison to baseline. Additionally, in Study 2 the use of both the tactile prompt and the prosthetic reinforcement were successfully faded. Implications regarding the use of covert prompting methods to help individuals with autism in the area of social interactions are being discussed.

One of the core deficits, and a diagnostic criterion for autism, is difficulties in the area of social interaction. More specifically, persons with autism may have impairments in the use of non-verbal behaviours (such as eye-contact and body posture), fail to develop typical relationships with peers, and participate in a limited way in reciprocal activities such as games (American Psychiatric Association, 2000). Even after language improvements have been achieved through intervention, social difficulties often continue to persist presenting challenges to professionals who work with individuals with autism (Weiss & Harris, 2001).

Initiating towards peers is one aspect of social interaction that seems to be especially problematic for young children with autism (Hauk, Fein, Waterhouse, & Feinstein, 1995). Data on the rate of verbal initiations that typically developing children emit towards their peers indicate that child characteristics and environmental variables result in variability among children (Greenwood, Walker, & Todd, 1981; Tremblay, Strain, Hendrickson, & Shores, 1981). A few researchers have suggested that on average, 3- to 6-year old typically developing children emit one initiation every two minutes during unstructured play situations (McGrath, Bosch, Sullivan, & Fuqua, 2003; Zanolli, Dagget, & Adams, 1996). Children with autism might initiate towards adults, but rarely spontaneously seek to interact with their peers (Koegel, Koegel, & McNerney, 2001; Oke & Schreibman, 1990). Therefore, conversations and interactive play between children with autism and other children are limited, resulting in reduced social and verbal learning opportunities (Koegel, Koegel, Shoshan, & McNerney, 1999b; Nikopoulos & Keenan, 2003). Furthermore, research comparing initiations of children with autism and those with intellectual disability shows that both the quantity and quality of initiations towards peers is lower for children with autism. In terms of quality, when initiations occur, they are of a lower developmental level (Hauk et al., 1995).

There is some evidence that social initiations might be a pivotal behaviour (or pivotal response class) for children with autism, which if successfully increased might result in improvements in the child's overall development (Koegel & Koegel, 2006). For example, the presence of a higher level of spontaneous initiations at pre-intervention correlated with better post-intervention outcomes for children receiving early behavioural intervention (Koegel et al., 1999b). In a second phase of the Koegel et al.(1999b) study, the authors systematically incorporated verbal initiations targets (first toward adults, and later extending to peers) in the intervention programs of four children with autism who lacked this skill. Initially the children were taught to ask an adult "what's that?" in the presence of a semi-concealed highly preferred item. Subsequent targets included initiations such as: "where is it?" and "whose is it?" involving items; "what is happening?" involving story books; and "play slide" towards a peer at the playground. Two 1-hour sessions were conducted weekly. After two and a half years of intervention, the four participants' verbal initiations showed marked improvement. The children also scored at an age-appropriate level in their pragmatic language skills, adaptive behaviour scores and social and community functioning (Koegel et al., 1999b). These findings suggest that incorporating social initiation training within early intervention programs might enhance overall effectiveness.

Previous behaviour analytic studies have explored a number of procedures to help increase the rate of social initiations in children with autism. Swaggart et al. (1995) used a social story combined with verbal prompting and reinforcement procedures to teach a girl with autism to greet her peers. A script and script-fading procedure was used in another project involving four children with autism (Krantz & McClannahan, 1993). Following this intervention, all children reached a similar level of initiations as their typically developing peers. Video modelling was employed in a study by Nikopoulos and Keenan (2007) who taught four children with autism to initiate towards an adult. These authors found that the newly acquired behaviour generalized towards a peer without further training. However, the generalization sessions were conducted in the same experimental setting as the previous sessions with the adult. No generalization check was conducted in a more naturalistic environment, such as the children's classroom or the playground.

Each of these existing studies incorporated the use of a prompting method to help the child initiate towards others. Prompts are defined as antecedent stimuli which can have a variety of forms (modelling, verbal, gestural, etc.) that cue the learner to emit the desired behaviour (Cooper, Heron, & Heward, 2007). Prompting methods have been widely and effectively used within Applied Behaviour Analysis (ABA) interventions when social skills are being targeted. However, a number of limitations relating to prompts being used in mainstream inclusive practice settings need to be considered. For example, overt prompts can be distracting for the child and for others in the environment and perhaps disrupt the flow of interactions. Overt prompts might also draw attention to the child's difficulties and thus make him appear as "different" from others (Anson, Todd, & Cassaretto, 2008). Another problem that often arises is that when the prompts are faded, the acquired behaviour may not be maintained (Odom, Hoyson, Jamieson, & Strain, 1985).

A prompting method that has shown some promise in helping children with autism emit verbal initiations towards their peers is the use of a tactile prompt. A tactile prompting device is a pocket sized vibrating pager that is either activated through a transmitter by a trainer or is programmed to vibrate at regular intervals. The individual is taught to associate the prompt with a specific behaviour. At the intervention stage, the teacher can activate the device to prompt the target person to engage in the desired behaviour. An important advantage of the method is that it is unobtrusive and covert. People other than the target person need not be aware that he/she is being prompted. Another consideration is that tactile prompts might be easier to fade compared to other prompting methods, such as verbal prompts.

A small number of studies have found the tactile prompt to be effective in teaching a variety of skills to young people with autism. Anglesea, Hoch, and Taylor (2008) taught three teenagers with autism to eat at a slower pace. A device programmed to vibrate at variable intervals (range 10 – 30 seconds) prompted them to take a bite at each vibration. Food consumption pace decreased for all three participants. Safety skills were targeted in a study by Taylor, Hughes, Richard, Hoch and Rodriquez Coello, (2004) who successfully taught three teenagers to seek assistance when lost in a community setting. At the vibration of the device (activated by a trainer invisible to the student with autism), the participant approached the nearest adult and indicated he needed assistance by handing him/her a communication card. Anson, Todd and Cassaretto (2008) used a tactile prompt to cue students with autism who attended a mainstream classroom to exhibit "on-task" behaviour (e.g. pay attention to the teacher or engage in appropriate activities). They compared this prompting method to verbal and gestural prompting and found that the covert, non-intrusive tactile prompt was at least as effective as the more traditional prompting methods.

We also found two existing studies in which a tactile prompting device was used to help children with autism make verbal initiations. Taylor and Levin (1998) used a device that could be programmed to vibrate at regular intervals to increase the spontaneous initiations of a nine-year-old child, Ron. During indoor play activities, Ron was taught to initiate to an adult using phrases such as "Mary, I am making a tiger!" Results indicated that Ron emitted between 8 and 10 verbal initiations per 10-minute session during the tactile prompt condition. Follow-up probes with typically developing peers showed that Ron emitted a high rate of initiations when the tactile prompt was activated. However, when the device was inactive in his pocket he made very few initiations. Shabani et al. (2002) used a device that was activated by a remote control and replicated Taylor and Levins' study with three children with autism. Children were taught to initiate to typically developing peers using the phrases: "Look at this", "I have..." (toy label), and "Do you want to play?" during free-play activities. Data on a second untrained behaviour - verbal responses to peers' initiations - were also collected. The authors found that the use of the tactile prompt resulted in increased initiations and responses. Fading of the tactile prompt by reducing the frequency of vibrations was attempted with two of the three children. This phase was partially successful with one child but the other child had a significant decrease of initiations during the fading procedure.

Existing research provides some evidence that the tactile prompt can be effective in increasing verbal initiations for children with autism. However, a significant question that has not yet been answered is whether it is possible to fade the tactile prompt while maintaining the increased levels of verbal initiations. A hypothesis that has not yet been tested is whether incorporating prosthetic reinforcement during the tactile prompt intervention might result in a more successful fading procedure. Reinforcement was not used by Taylor and Levin (1998) and was only used during the training phase in the Shabani et al. (2002) study. Accordingly, the present project comprised of two studies aimed to replicate and extend the existing research on the subject by: (a) incorporating the use of reinforcement during the intervention phase, and (b) attempting fading of both the tactile prompt and the prosthetic reinforcement.

Study 1

Method

Participants

Three boys diagnosed with autism participated in the study. All were attending an autism unit attached to a mainstream elementary school in North Wales, UK. Children enrolled in the unit received ABA based individualized intervention (see Grindle et al. 2009; 2012). As part of the ongoing annual assessments administered to all the students in the unit, the three participants were assessed for IQ and adaptive behaviour scores. The tests were conducted towards the end of the intervention period independently of the present study.

Alex was 7 years, 3 months old. At the time of the study he spent a large proportion of his school day in the mainstream classroom accompanied by an ABA-trained therapist. He could talk in full sentences. He enjoyed participating in play activities with his mainstream peers. However, he rarely initiated verbally towards his peers. His IQ score on the Stanford–Binet Intelligence Scale–Fourth Edition (SB-IV, Thorndike et al., 1986) was 93. On the Vineland Adaptive Behavior Scale–Survey Form (VABS, Sparrow et al., 2005) he had a composite score of 79, communication 86, and socialization 80.

Peter was 6 years, 2 months old. He had good language skills and would often approach adults and verbally initiate. However, he had a low level of interactions with other children and he generally chose to play by himself. During playtime, he would sometimes say a phrase related to a favourite cartoon story (e.g. "I'm Jono the dog!"), without directing this to another individual. Peter had an IQ score of 102 on the SB-IV and his composite score on the VABS was 79, while his scores on the communication and the socialization domains were 93 and 77 respectively.

Reuben was 4 years, 6 months old. He could talk in sentences consisting of up to three words. During playtime, he would engage in parallel play alongside other children but did not interact with them. Reuben had an IQ score of 83 on the SB-IV. His adaptive skills standard scores on the VABS were: composite 68, communication 74, and socialization 68.

Settings

Based on each child's individualized program in the unit, an intervention setting was chosen that would offer the most opportunities for interactions with peers. An additional goal was to implement the intervention in a setting with mainstream peers rather than other children with autism so that any initiations the participants made would have more possibilities of being reciprocated. Alex spent most of his daily free-play time in the large play yard of the mainstream school with typically developing peers. Therefore, this setting was chosen for him. Football games were often played in this yard, an activity Alex enjoyed. There were also markings on the ground for playing hopscotch and jumping circles. An indoor setting was chosen for Reuben who spent about half an hour daily in a free-play area of the pre-kindergarten with typically developing children who were approximately a year younger than him (3-year-olds). Toys in this setting included building blocks, cars, trains and a doll's house. There were also a few tables used for activities such as drawing, painting or play-dough. Peter did not spend time in mainstream school at the time of the study because he exhibited high levels of anxiety in that setting. Consequently, we could not implement the intervention in a free-play setting with mainstream peers. Instead, we used the small play yard that children of the autism unit shared with children from the mainstream kindergarten class. Subsequently, Peter had opportunities to initiate towards both children with autism and typically developing children. There was a slide in this play yard and a variety of outdoor toys such as bikes, water play materials, strollers and dolls.

The training phase with each of the children (see Procedure) was conducted at their individualised teaching area within the ABA unit. This was divided from the rest of the classroom by a screen and was equipped with a table and small chairs, a set of drawers for teaching materials and shelves for favourite books and toys the child used at play-times.

Materials

A Motivaider®, a pager small enough to fit into a child's pocket, was used as a tactile prompt. The device can be programmed to vibrate at different intervals and strength of vibrations can be adjusted within a range of "1 to 5". "Rule cards", that were read with the children during the training and intervention phases, were created. The rule cards we used with Alex and Peter (see Appendix 3) contained five questions they could ask of their peers. For example: *"I can get tokens for asking my friends questions. I can say: When is your birthday? Where do you live? Can I play with you? What's your favourite TV programme? Do you have any pets? A buzzer will remind me when to ask a question to a friend."* To help the children vary their questions, five rule cards with the questions presented in a different order were used. In accordance with his language skills at the time of the study, a simpler rule card was used with Reuben who was taught only two initiations: "*Hello!*" and "*Can we play?*"

A token economy reinforcement system was used with all three children who were already acquainted with its use. Individual token boards contained 10 tokens and were based on the child's interests (e.g., tokens had pictures of favourite cartoon characters). We also used digital timers to measure duration of observations. Data sheets appropriate for event recording of each dependent measure and for general note-taking, were designed for the needs of the study.

Dependent measures

Data on two dependent measures were collected: (a) the number of verbal initiations the target child made towards peers and, (b) the number of verbal responses peers made to the target child's initiations.

Verbal initiations were defined as: "audible, appropriate (socially, and in context) vocal verbalizations, directed towards another person or a group of persons in the absence of an existing interaction". An initiation could have the form of a question or a statement, and did not necessarily need to be a full sentence as long as it could be understood (e.g.

"coming!" or "look!" would be recorded as appropriate). To be characterized as "directed towards another" the initiation had to be accompanied by some form of non-verbal behaviour indicating the recipient (e.g., making appropriate eye-contact, or the child's face being turned towards the peer while asking a question). Non-appropriate initiations (e.g., utterances out of context, echolalic phrases) or initiations not directed to another person were not recorded. For example, when Peter shouted "I am going to crash!" and "I am Scooby!" while riding a bike, these phrases were not recorded as initiations as they were not directed to anyone in particular.

Verbal responses were defined as: "vocal verbalizations that are audible, uttered within 3 seconds of another's initiation, socially appropriate, and relevant in content to the initiation". Responses that were not clearly audible, were inappropriate, had no relevance to the verbal initiation, or were delayed (longer than 3 seconds after the initiation) were not recorded.

An event recording system was used for recording both behaviours. Each instance of target behaviour was recorded as a tally on the data sheet. Additionally, to ensure accurate data collection (i.e., that an initiation was appropriate), observers took brief notes on the verbal interactions taking place during the observation period.

Design and Procedure

An ABAB single case design was used and replicated across the three children. Phase A (baseline) was followed by intervention with implementation of the tactile prompt (phase B). Then a return to baseline (A) was conducted and finally a second intervention phase (B). Observations typically lasted for 10 min and were conducted once a day during free-play activities with peers. A training phase was implemented after the end of the first baseline period.

Baseline. The child was observed during free-play activities at the intervention setting (play-yard or indoor play area). Data on the number of verbal initiations the target child made to his peers and peers' responses to the target child's initiations were recorded. No prompts were given to either the target child or his peers, and when interactions occurred no systematic reinforcement was provided.

Training phase. To teach the children to respond to the vibrations of the tactile prompt with social initiations, a systematic teaching procedure similar to the one used by Taylor and Levin (1998) was designed (Appendix 2). Training sessions were conducted at the child's individual teaching area within the autism unit (except for the final 2 stages of the training procedure). Two training sessions, each lasting approximately 10 min, were conducted daily by the ABA therapists who normally worked with the child under supervision of the authors. For each step of the teaching procedure, the child had to achieve a mastery criterion of five consecutive correct responses before training of the next step began. It was possible to teach more than one step within a session, depending on individual progress. Trial-by-trial data were recorded during training. Duration of the training phase was on average 24 sessions (range 18 - 30).

The token economy reinforcement system was used during the training phase. At the beginning of the session, the child was informed that he would be earning tokens. Once all the tokens were collected, he could choose a preferred activity from a list of backup reinforcers. Reinforcing activities included spending a few minutes of extra play-time in the school yard, playing a computer game, reading public notices displayed in various parts of the school, or a trip to the local shops at the end of the day.

The training procedure consisted of eight stages (see Appendix 2). During the first five, the prompting device was programmed to vibrate at a 30-sec fixed interval (FI).

1. *Familiarization with the tactile prompting device*. The aim of stage one was to ensure that the vibration of the pager did not distress or startle the child. Initially, the Motivaider® was placed on the table and the child was asked to place his hand on top of it, then it was placed in the child's pocket with his hand on top of his pocket, and finally it was in the child's pocket without the child touching it (i.e., the therapist asked him to place his hands on the table).

2. *Making a verbal initiation when the tactile prompting device was on the table and the child's hand on top of it*. The aim of stage two was to teach the child to make appropriate verbal initiations at each vibration of the pager. The therapist told the child they would be practicing how he could ask questions of his friends and read the rule card with him. Then the device was placed on the table and every time it vibrated the child was verbally prompted to ask the therapist one of the questions on the rule card (the therapist said "ask me a question" while pointing to one of the questions on the rule card). A most-to-least prompting procedure was followed, so after the child made five correct initiations with the verbal prompt, only the pointing prompt was used. When this step was mastered, the pointing prompt was faded and the child was expected to independently ask a question at each vibration. For each correct response, the therapist provided an appropriate answer to the child's question and placed a token on the token board. Correct responses were defined as: "asking a different question on the rule card on consecutive trials, or a socially appropriate question not included on the rule card, in a clear voice". In the case of an incorrect response (e.g., repeating the same question twice in a row, making a non-appropriate initiation, using unclear speech), the therapist prompted a correct response. Every five trials, a different rule card was presented to help the child vary the order of the initiations.

3. *Initiations when the device was in the child's pocket and his hand on top of his pocket.* After reading the rule card with the child, the Motivaider® was placed in the child's

pocket. At each vibration, the child was expected to make an appropriate verbal initiation to the therapist. Because of the high levels of prompting used in the previous stage, a least-to-most prompting procedure was used during stage three.

4. *Initiations with the device in the child's pocket and his hands not touching it.* Similar to Stage 3, but this time the child was instructed to place his hands on the table.

5. *Initiating while making eye-contact*. The aim for this stage was for the child to look at the person to whom he was initiating.

6. *Repeating the question when the other person does not respond.* The aim of stage six was to teach the child to persist when the therapist did not answer his question the first time. A 45-sec FI was used to allow for time to repeat the question. Reuben did not receive training on this stage as it was considered to be too advanced for him.

7. *Generalization training at the intervention setting*. To ensure that all the previously acquired skills (asking a question when the tactile prompt vibrated with eye-contact, repeating questions) would be demonstrated outside the training setting, sessions were conducted at the setting in which the intervention was programmed to take place (playground or indoor play area). Vibrations of the tactile prompt were programmed at 1-minute intervals. The child was instructed to play as usually in that setting, and at each vibration of the pager in his pocket to approach the therapist to ask a question. Correct responses were rewarded with tokens.

8. *Generalizing initiations to a different person, and delayed delivery of reinforcement*. During this final training stage (conducted at the intervention setting similarly to the previous stage), the child was expected to initiate towards an adult who had not been

involved with the training previously. At the end of the session the therapist “debriefed” the child and delivered all tokens.

Tactile prompt intervention. The therapist accompanied the child to the intervention setting (play yard or indoor play area) and together they read the rule card. This reminded the child that they could be earning tokens for talking to their friends. The child was then asked to choose for what he would like to exchange his tokens. Next, the prompting device was placed in the child’s pocket, and programmed to vibrate at 1-minute intervals. For the next 10 minutes, the child played in that setting. The therapist and the person(s) collecting data observed the child from a distance that would allow them to listen to his verbal interactions while being as discreet as possible. At the end of the 10-minute period, the therapist approached the child to debrief him, show him the tokens he had earned, and remove the tactile prompt. If all ten tokens had been collected, reinforcement was delivered at the end of the session. In some cases, the child had selected an activity that would take place at a later point (e.g., a trip to the shops). If not all tokens had been collected during the observation session, the child was praised for the initiations he had made and was encouraged to try again to collect all his tokens the next time.

Additional training lasting three sessions at the beginning of the tactile prompt intervention phase was necessary for Reuben because he would approach an adult (the ABA therapist who accompanied him in the mainstream setting) and initiate to her when the device vibrated. Verbal prompts to “talk to a child” were ineffective. Then the therapists were instructed to ignore Reuben’s initiations to them (avoiding eye-contact as well). If he persisted initiating to the therapist, she would provide a non-verbal prompt of pointing to one of the children. This procedure was effective with Reuben, who started initiating towards his peers.

Fidelity of implementation, and interobserver agreement

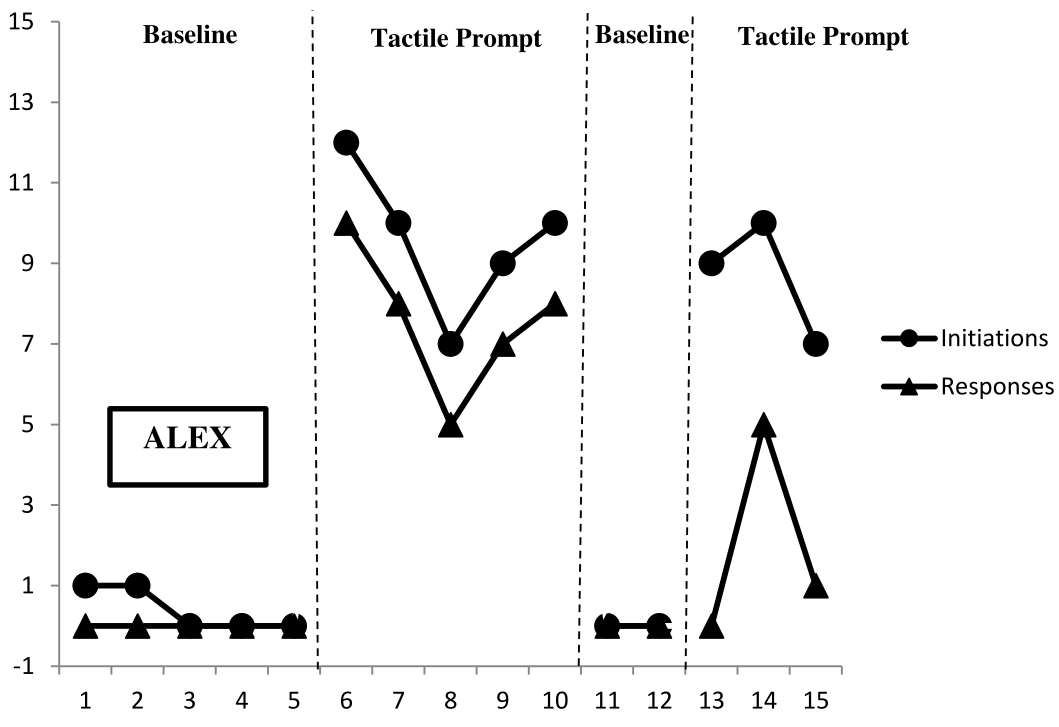
Prior to the beginning of the study, a training session with the teaching staff of the unit was conducted by the authors. The rationale, procedure, and materials of the project were presented. Role-play with the therapists working in pairs (one playing the role of the child) was used to help demonstrate the different stages of the training procedure. To ensure procedural fidelity during the training phase, daily observations of the therapists working with the children were conducted either by the second (CG) or the fifth author (MS) who were working as consultant and supervisor in the autism unit respectively.

For interobserver agreement purposes, a second person trained in data collection observed 24% of baseline and intervention sessions. Inter-observer agreement (IOA) was calculated by dividing the total number of agreements, by the total number of agreements and disagreements, multiplied by 100. On average, IOA was 95% (range 80% to 100%). IOA for individual children was: 93% for Alex (range 80% to 100%), 96% for Peter (range 85% to 100%), and 95% for Reuben (range 90% to 100%).

Results

For all three participants, the number of initiations to peers increased during the tactile prompt phases (Figure 2.1). During the baseline phases, Alex made on average 0.28 (range 0 to 1) initiations in 10 minutes, whereas when the Motivaider® was in his pocket his initiations increased to an average of 9.25 (range 7 to 12 during the two intervention phases). Peter's initiations during baseline were on average 1.1 (range 0 to 2) and during the tactile prompt phases he made an average of 6.36 initiations (range 1 to 13) per 10-min session. Finally, Reuben made no initiations during the baseline phases, whereas during the tactile prompt phases he made on average 7.87 initiations in 10 minutes (range 5 to 10).

Results relating to peers' responses to the initiations of the target children show some variability. Alex received responses to most of his initiations to his mainstream peers. Sessions 13 and 15 that show a very low number of responses were conducted in a different play-yard with other children with autism who did not respond to his initiations. For Peter, many of the sessions were conducted when only children with autism were present in the play-yard and they usually did not respond to his initiations. Reuben's peers were younger (3-year-old) typically developing children. During the intervention sessions, Reuben would interrupt his solitary playing at each vibration of the device, approach a peer and saying "Hello!" He would then go back to the activity in which he had been engaged. Reuben rarely received a response from the peer, possibly because he did not wait for peers to respond.



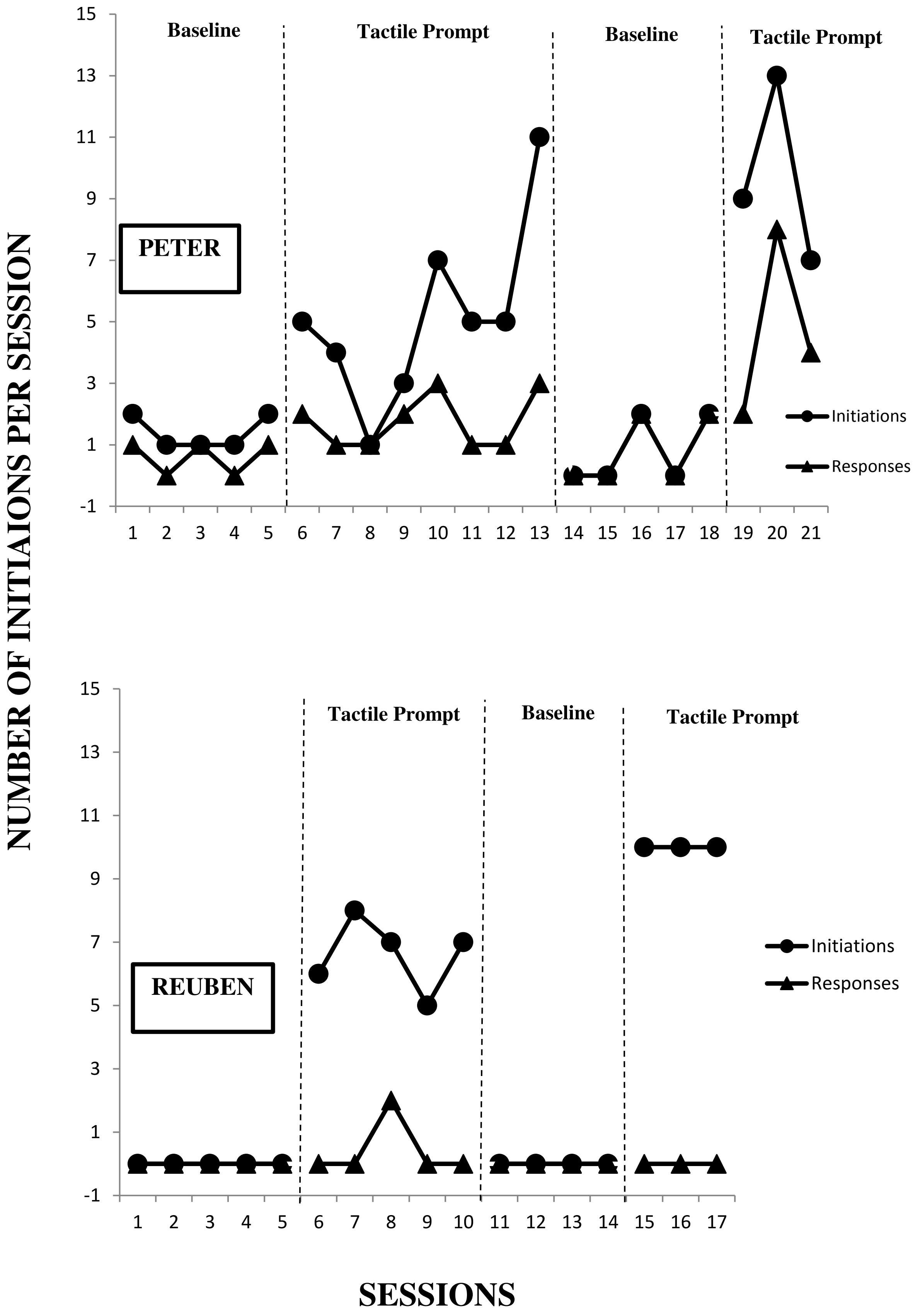


Figure 2.1: Initiations to peers and peers' responses for Alex, Peter and Reuben

Discussion

The results indicate that the use of the tactile prompt combined with prosthetic reinforcement resulted in all three children increasing their rate of initiations towards peers. This replicates and extends findings from previous studies. Alex and Reuben made practically no initiations prior to the intervention. They both initiated at a rate higher than that expected from typically developing children (one initiation per two minutes, McGrath et al., 2003) during the tactile prompt phase. Peter had a slightly higher level of initiations during baseline and his data in the intervention phase show more variability. However, his overall level of initiations increased considerably during the intervention. Peter sometimes continued the conversation with the peer after the first initiation. For example during session 8, he had the following interaction with a typically developing peer:

Peter: "*Have you got any pets?"* Peer: "*Yes, I've got a muggy*"; Peter: "*A muggy? What's a muggy*?" Peer: "*It's a muggy";* Peter: "*But what's its name?"*

Alex often started his initiation with an introductory phrase like: *"Excuse me"* or *"I have a question for you"*. However, he only asked the five questions on the rule card. Towards the end of the study a peer replied to his initiation with: "*You asked me the same question yesterday."* Given that teaching a larger repertoire of initiations might benefit some of the children, this was an issue that we targeted in Study 2.

Time restrictions (school closure for the summer vacation) resulted in the termination of the study at the end of the second intervention phase. We were, therefore, unable to attempt fading of the prompts (rule card and Motivaider®) and of the prosthetic reinforcement as was our initial intention. This was a limitation of Study 1 because an important aim of any behavioural intervention is the removal of artificial stimuli and the occurrence of the desired behaviour under natural environmental circumstances (Sulzer-

Azaroff & Mayer, 1991). The aims of Study 2 were to replicate the procedures of Study 1 with different participants in a different setting, and to extend the procedure by attempting a gradual fading of the prompts and reinforcement.

Study 2

Method

Participants, settings and materials

Two children with a diagnosis of autism living in North England, UK, participated in this study. Both were receiving home-based ABA intervention and were attending school full-time. Victor was 7 years old and was enrolled in a special needs school. Katie was 9 years old and attended a mainstream school with one-to-one support. Both children were able to verbally communicate using full sentences and did initiate to adults. Spontaneous interactions with their peers were limited (e.g., on occasion both Victor and Katie would say to a peer “play with me!” or “can I play with you?”). IQ and adaptive behaviour measures were not available for the two participants of this study.

The setting of the intervention for Victor was an Out-of-School club he attended three afternoons a week with typically developing children. The club had a play area with boxes of different toys (building blocks, cars, a doll’s house), a role-play area, a kitchen-play area, a sand play corner, a games console area, and tables for drawing, painting and board games. The school playground was chosen as the intervention setting for Katie. A box with outdoor play items such as skipping ropes and balls was available to the children during playtimes. There were also markings on the ground for playing “What’s the time Mr Wolf?”, hopscotch and football.

Training sessions for both children were conducted at their homes, during their ABA sessions with a therapist who normally worked with them. The teaching area consisted of a table and chairs, bookshelves, a sofa, and a TV set.

Similarly to Study 1, a Motivaider® was used as the tactile prompting device. Individualized rule cards with questions relevant to each child's interests and intervention setting were created. To help the children vary their initiations, a larger number of questions were included in the rule cards used in Study 2 (Appendix 3). Katie was taught 10 different questions (e.g., *"Do you have a wii?", "Do you want to have a running race?", "Do you want to dance like Britain's got talent?"*), and Victor eight questions (e.g., *"What are you playing?", "Can I play too?", "Do you want to play Pirates?").* Token boards containing 10 tokens each, were also used.

Dependent Measures and Design

As in the previous study, the dependent measures were the number of verbal initiations the target child made to his peers and the peers' responses to the target child's initiations during each 10 min session. A single case ABABCDA design, a variation of a reversal design, was used. Baseline (phase A) was followed by the implementation of the tactile prompt intervention (phase B), a return to baseline (A) and a second intervention period (B). Two fading phases were conducted next; during the first the tactile prompt was systematically faded (phase C) and then the use of reinforcement was also withdrawn (phase D). A third baseline phase (A) was implemented after the end of the fading phases. Finally, a follow-up session was conducted with each participant approximately 6 weeks after the end of the study.

Procedure

The general procedure was similar to Study 1.

Baseline and tactile prompt phases. These phases were identical to Study 1. Each child was observed for a 10 min interval during free-play activities with mainstream peers and data on the target child's verbal initiations towards peers and peers' responses to the target child's initiations were recorded. Sessions were conducted approximately three times a week. A variety of preferred items and activities were used as backup reinforcers during the tactile prompt phase, including access to specific books and magazines, video games, a trip to the shops, and chocolate.

During the second tactile prompt phase, use of the rule cards was gradually faded. Because the children were becoming acquainted with their contents, at the beginning of each session the therapist would give them a choice of whether they wanted to read the card. During consecutive sessions the children asked for the cards to be read less frequently until they were not used at all towards the end of this phase.

Training phase. Training was conducted at the end of the first baseline phase and was identical to the training described in Study 1. Training took place at each participant's home, during ABA therapy sessions. Approximately twelve 10-min sessions were conducted with Katie, and 18 sessions with Victor.

Tactile prompt fading phase. Upon successful second implementation of the tactile prompt intervention, a procedure of fading the use of the device began. As an initial step, the interval time between vibrations was increased from a fixed interval (FI) of 1 minute to a FI of 2 minutes. A second step (implemented during the second session of this phase for Victor, and the third session for Katie) involved gradually fading the strength of the tactile prompt vibrations. The Motivaider® vibration strength which had been set at level 3 during intervention was reduced to level 2, then 1, and then it was placed in the child's pocket without being activated. Finally, the device was removed completely. The use of reinforcement continued as previously during this phase.

Reinforcement fading phase. The aim of this final fading phase was to remove the use of the token board and the external reinforcement while maintaining a high level of social initiations. Time constraints (the approaching end of the school year) resulted in this phase being short. Two sessions were conducted with Victor. Initially, the schedule of reinforcement was reduced from a continuous one (FR1 ratio – a token for every initiation) to a variable ratio of 3 (VR3 – a token for approximately 3 initiations). In the next session, Victor was given a single token at the end of the 10-minute session contingent on his initiating at the level of a typically developing child (one initiation every two minutes, see McGrath et al., 2003). A single session was conducted with Katie, and the reinforcement was reduced from an FR1 ratio to a single token given at the end of the session. Similarly to Victor, her target was to make approximately one initiation every 2 minutes. The token economy system was then removed completely and a return to baseline condition followed.

Interobserver Agreement

A second observer, trained in data collection, was present for 25% of observations. The mean inter-observer agreement across baseline and intervention phases was 97% (range 90 -100%) for Victor and 99% (range 96-100%) for Katie.

Results

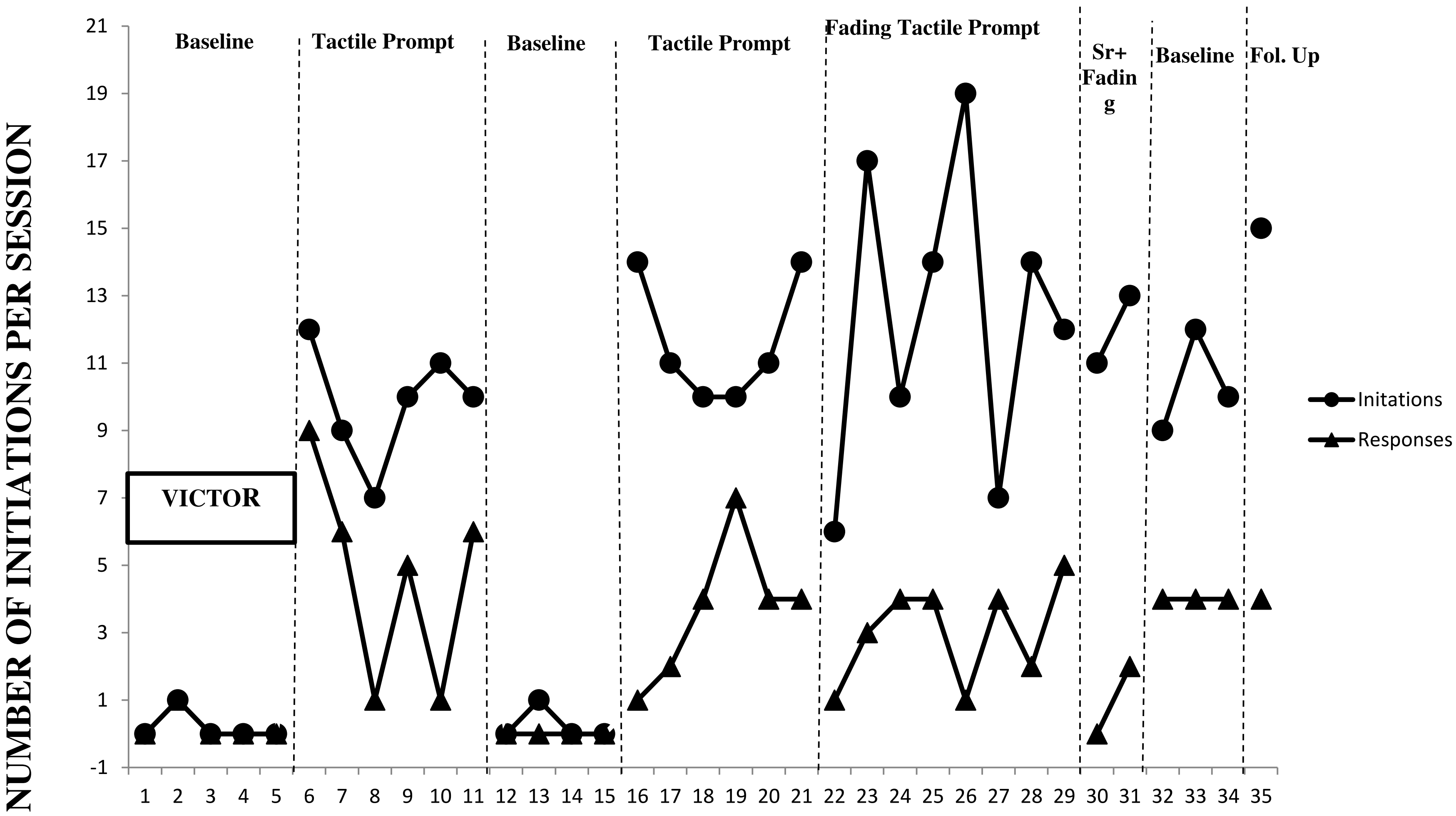
The number of initiations towards peers increased for both children during the tactile prompt phase (see Figure 2.2). The mean number of initiations during the first and second baseline phases was 0.22 for Victor (range 0 to 1) and 0.33 for Katie (range 0 to 1) within a 10-minute interval of free play activities. When the tactile prompt was activated, their average initiations were 10.75 (range 7 to 14) for Victor and 10.4 (range 7 to 17) for Katie (see Figure 2.2). Improvements were maintained during the phases where fading of the tactile prompt and reinforcement were carried out. Victor's data showed a greater variability during the first fading phase (range 6 to 19 initiations). During the final return to baseline phase, Victor made an average of 10.3 initiations in 3 sessions and Katie 9 initiations (1 session). During the follow-up observation conducted six weeks after the last data point, Victor made 15 initiations and Katie 6 within a 10-minute period.

Peers' responses to the target child's initiations during the tactile prompt phase averaged 4.1 (range 1 to 9) for Victor and 5.3 (range 1 to 8) for Katie.

General Discussion

Findings of previous similar studies (Shabani et al., 2002; Taylor & Levin, 1998) were replicated in both studies. Use of a tactile prompt during free-play activities resulted in increased frequency of initiations of five children towards their peers. Importantly, the intervention was conducted in five different settings, which included both indoor and outdoor free-play areas, equipped in some cases with many and in others with a few play materials. In addition, training was implemented by different teaching staff and the language skills levels of the participants varied.

To our knowledge, Study 2 is the first to have achieved a successful removal of the tactile prompt. In Study 2, when first the pager and then the use of the token board and reinforcement were systematically faded, both children maintained a high level of initiations and the gains were still in effect six weeks later. This was an important finding since a limitation of any prompting method is that when prompts are withdrawn behaviour changes


NUMBER OF INITIATIONS PER SESSION
Baseline
Tactile Prompt
Baseline
Tactile Prompt
Fading Tactile Prompt
Sr+ Fadin g
Baseline
Fol. Up
VICTOR
Initations
Responses
21
19
17
15
13
11
9
7
5
3
1
-1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35

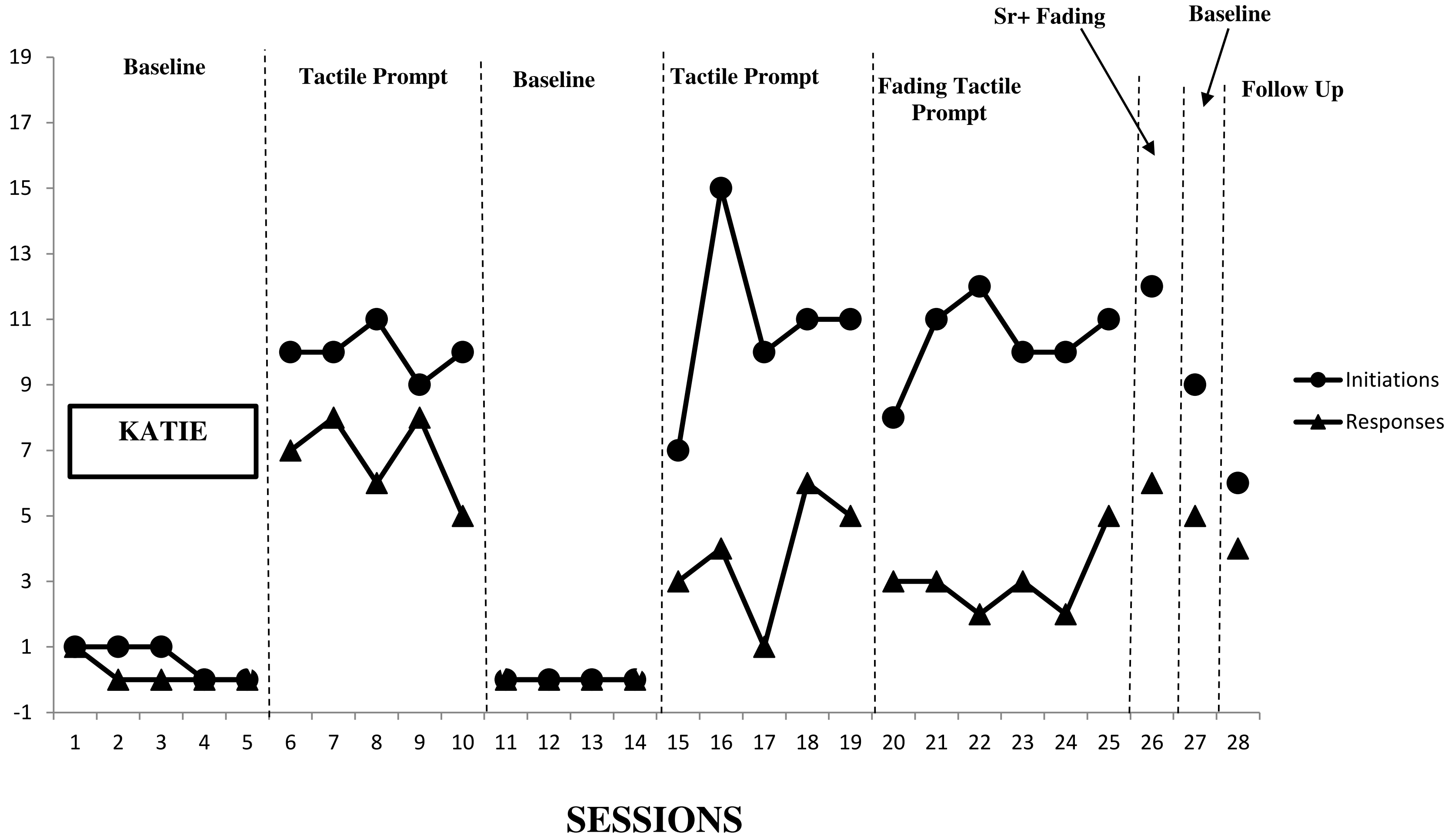


Figure 2.2: Initiations to peers and peers' responses for Victor and Katie

may not be maintained (Odom et al., 1985). Removal of the tactile prompt has either not been targeted (Anson et al., 2008; Taylor & Levin, 1998) or has been partially successful (Shabani et al., 2002) in previous research. Shabani et al. (2002) attempted fading the tactile prompt with two of their three participants. However, only one child continued to initiate at a desirable level during the fading phase and initiations of the other child decreased considerably. Two factors might account for the success of the fading phase in our Study 2. The first is that reinforcement based on a token system was implemented during the training phase, and we continued to use it during the intervention period and then throughout the tactile prompt fading phase. In the Shabani et al. (2002) study, reinforcement was only used during the training phase. Considering the challenge that social initiations present for children with autism, it is logical to expect that control of this behaviour may not automatically be transferred from an external prompt to natural reinforcers such as the pleasure a typically developing child derives from interactions with other children. Therefore, it is possible that the use of additional reinforcement played a critical role in the overall success of the intervention.

The second factor contributing to the success of the fading procedure may have been the implementation procedure itself during this phase. It is interesting that when the interval between vibrations was increased from 1 minute to 2, both Victor's and Katie's levels of initiations decreased. When the vibration strength was gradually decreased during the following sessions, both children had a higher level of initiations. This suggests that fading the strength rather than the frequency of vibrations might be a more effective way of removing the tactile prompt while maintaining a high level of initiations. Finally, successful fading of the tactile prompt and external reinforcement was achieved after an intervention of a longer duration. The Shabani et al. (2002) study was conducted over 18 to 19 sessions, and our Study 1 over 15 to 21 sessions. In Study 2, on the other hand, 28 sessions were conducted with Katie and 35 with Victor (including the follow-up session).

Even with the added time needed for the fading phases, the present research represents a relatively short and cost-effective intervention. Another advantage of the intervention is that the procedure can easily be adapted to correspond with individual children's needs. For example, the number, length, and content of phrases on the rule cards can be adjusted and some steps of the training procedure may be omitted if they are too advanced for the child (as we demonstrated with Reuben's training and rule card).

Transcripts of individual initiations and responses indicate that quality of interactions between the target children and their peers differed among participants, although all of them showed marked improvements compared to baseline. Reuben simply used the initiation "hello" for the duration of the intervention. However, during the course of the study he progressed from not having any interactions with peers to confidently walking towards different children in the play-room and saying "*hello*" with good eye-contact and a clear voice. Alex only used the five questions on the rule cards, although he often began his initiations with a spontaneous introductory phrase like "*excuse me*" or "*I have question for you*". Peter, Victor and Katie on the other hand, often used their own phrases or adapted the ones they had been taught. For example, Katie who had been taught the initiation *"can I play too?"* asked a peer during session 8 *"what else can we play instead of that?"* These three children also sometimes prolonged the interaction by asking more questions on the same topic.

As reflected in the data on peers' responses to the target child's initiations, not all initiations made by the children with autism were reciprocated by their peers. A partial explanation is that some of the children's initiations were statements rather than questions.

For example, in session 16 Victor's initiations included: "*After them Kiam!*", *"You'll go after him and I'll go after him!", "I can't scare you!"* Another consideration is that whereas a typically developing child makes approximately one initiation every two minutes (McGrath et al., 2003) the target children initiated at a much higher rate during the intervention. This might have had a negative impact on the peers' perception of the child with autism. It is also possible that in some cases the child with autism made an initiation that interrupted the other child's play. An instance during session 8 with Alex illustrates this point. Alex asked a peer twice *"Can I play?"* to which the peer responded *"Shhh....I am hiding!"* Alex's behaviour indicates that he had successfully learned to persist when a peer did not respond the first time. However, he did not perceive that it was inappropriate to initiate to a child who was hiding during a "hide and seek" game.

Our findings suggest that while the tactile prompt can be effectively used to increase frequency of initiations other, perhaps more subtle, aspects of social skills also need to be targeted to ensure that children with autism develop successful social interactions with their peers. Peer reciprocity is a key element in social relationships (Weiss & Harris, 2001). Therefore, future research should further investigate this area. It is possible that reinforcing peers' responses to the target child's initiations during the tactile prompt intervention will result in an increase in responding. An alternative option would be to implement a social skills training program prior to, or in combination with, the tactile prompt intervention. For example, Kamps et al. (1992) conducted social skills training within small groups which included high-functioning children with autism and typically developing peers. They targeted a variety of social skills such as initiating and maintaining interactions, conversations on different topics, giving and accepting compliments, helping others and accepting help, and they found that children with autism and their peers improved their social performance.

A limitation of the present studies is that to listen to the target child's interactions, observers had to stand at a relatively close proximity to the child, especially in outdoor settings. This might have to some degree compromised the non-obtrusive character of the prompting method. Possibly, attention was drawn to the target child or the spontaneity of children's interactions might have been impacted. In future, researchers could consider using a recording device so that the child's interactions can be assessed after the end of the observation period. Audio recording would also allow for a more precise assessment of the quality of interactions.

In conclusion, the present findings support and extend previous knowledge on the use of a tactile prompting device to increase the rate of social initiations in children with autism in free play settings with typically developing peers. Further research is necessary, especially in the area of improving the quality of interactions between children with autism and their peers.

Chapter 3. Teaching Mathematics to Children with Autism: A Systematic Review

Abstract

The purpose of this review is to provide a systematic analysis of empirical studies investigating interventions to teach mathematical skills to students with autism spectrum disorders (ASD). Sixteen studies were analyzed. Six of these targeted exclusively mathematical skills and all participants had an ASD diagnosis; the remaining ten studies included participants without autism and/or targeted non-mathematical skills as well. Separate analyses of these two categories were conducted. A variety of interventions were used in the reviewed studies, including different prompting methods, teaching of specific mathematical skills, and making changes to the environment to facilitate learning. The majority of studies reported positive results. The methodological strength of the reviewed studies was evaluated. Implications for practitioners and future researchers are discussed.

Deficits in social and communication development, and the restricted interests of persons with autism spectrum disorders (ASD), often mean that pupils with ASD have difficulties functioning in a school classroom (Machalicek et al., 2008). As a consequence, acquisition of academic skills such as reading, writing and mathematics can be problematic for these students who might either find the tasks too difficult or lack the motivation to engage with them (Koegel, Singh, & Koegel, 2010).

Research investigating academic attainment of students with ASD has mostly targeted literacy skills. Two systematic reviews have explored this area. Chiang and Lin (2007b) reviewed 11 studies on reading comprehension instruction. A variety of instructional strategies were used including discrete-trial teaching, incidental teaching, computer-based video instruction, the use of flash cards, and peer tutoring. The review results indicated that students with ASD successfully acquired the reading comprehension skills targeted. In a more recent systematic review on computer-based interventions designed to improve literacy skills in students with ASD, Sathiyaprakesh et al. (2011) located 12 relevant studies. Literacy skills targeted included construction of words and sentences, phonological awareness, reading, and receptive and expressive language. Results however were inconsistent: the studies using a quantitative analysis produced effect sizes ranging from large to non-significant and studies that conducted qualitative analyses reported positive, negative, or mixed results.

Very little information is available about interventions designed to teach mathematics to school-aged children with ASD. In a systematic review of school-based interventions for children with autism, Machalicek et al. (2008) reviewed studies aiming to increase a wide repertoire of skills, including academics, communication, functional life skills, play, and social skills. Academic skills were targeted in five studies and in two of these a mathematical skill was taught. Interventions in the area of academics resulted in positive changes for 78%

of participants. It was not possible to draw any strong conclusions regarding mathematics, because of the small number of studies that focused on this subject. In their meta-analysis on teaching mathematical skills to individuals with significant cognitive disabilities, Browder, Spooner, Ahlgrim-Delzell, Harris and Wakeman (2008) analyzed 68 studies, 12 of which included participants with an ASD diagnosis. However, no separate analysis of these 12 ASD studies was conducted.

With the present review, our aim was to address this gap in the literature and to systematically explore studies that have taught at least one mathematical skill to pre-school or school-aged students with ASD. Mathematical content includes the following five standards (areas) according to the Principles and Standards of School Mathematics published by the National Council of Teachers of Mathematics (NCTM, 2000): (a) The *Numbers and Operations* standard involves the abilities of understanding numbers, knowing the meaning of operations (i.e., addition, subtraction, multiplication, and division), and computing fluently; (b) *Algebra* involves understanding patterns and relations among sets of numbers, using algebraic symbols to represent and analyze mathematical situations, and using representations such as graphs, tables, and equations to represent quantitative relationships; (c) G*eometry* involves understanding the properties of two- and three-dimensional geometric shapes, describing spatial relationships and solving geometrical problems by applying spatial reasoning and geometric modelling; (d) *Measurement* involves understanding the measurable attributes of objects (i.e., length, volume and weight, time, and money) and being able to apply appropriate techniques and formulas to determine measurements; and (e) *Data Analysis and Probability* refers to the ability to formulate questions and use appropriate methods to collect and analyze data, and to develop data-based predictions and conclusions.

In addition to mathematical *content standards*, five *process standards* refer to ways mathematical knowledge is built and applied (NCTM, 2000): (a) *Problem solving* involves the process of addressing unfamiliar complex situations; (b) R*easoning and proof* refers to processes of analytically investigating mathematical phenomena; (c) C*ommunication* refers to the ability to clearly express and justify mathematical ideas; (d) C*onnections* involve the ability to synthesize mathematical knowledge from different content areas and everyday life; and (e) R*epresentations* involve the ability to use various ways (e.g., pictures, objects, symbols, tables) to depict mathematical situations and ideas.

The purpose of the present systematic review was to explore: (a) the mathematical skills that have been targeted, and the content and/or process standards represented within the literature with students with ASD; (b) evidence for strategies that have been used for teaching mathematics to this population; and (c) the methodological quality of research evidence by using the Scientific Merit Rating Scale developed by the National Autism Center (2009).

Method

Literature search procedure and inclusion criteria

We conducted electronic searches using the ERIC and PsychINFO databases up to June 2012. Two groups of terms were used: (a) terms for autism including *autis**, *asperger**, *PDD, pervasive developmental disorder, PDD-NOS,* and (b) a list of mathematical terms (e.g., *math*, numer*, number*, count, arithmetic, computation, problem-solving, addition, subtraction, algebra*, geometr*, measurement, graphing, shape, money, time).* Additionally, we examined the reference list in the Browder et al. (2008) review and conducted manual searches of studies citing identified articles. Searches yielded over 4000 articles. Titles and abstracts of these studies were checked by the first author. This initial screening resulted in the selection of 33 papers that were obtained for a more detailed coding.

We used the following inclusion criteria: (a) Participants had to be pre-school or school-aged children (3 to 18 years of age); (b) The children had to have a reported diagnosis of autism/ asperger syndrome/ PDD-NOS (if typically developing children, or children with a different diagnosis were included, data of children with autism had to be presented separately); (c) The study had to describe an educational intervention designed to teach one or more of the mathematical skills defined by the NCTM (2000) standards; (d) One or more measures of mathematical skills had to be reported as dependent variables; (e) Data demonstrating changes purportedly due to the intervention had to be available (at a minimum, a single group pre-test post-test design or an A-B single case design); and (f) The study had to have been published in a peer-reviewed journal.

Sixteen studies met the criteria for inclusion in the review. The 17 remaining studies were excluded for the following reasons: (a) Five did not report data focused on children with an autism diagnosis (Cote et al., 2010; Djuric- Zdravkovic, Japundza-Milisavljevic, & Dragana, 2011; Everhart, Alber-Morgan, & Park, 2011; Skibo, Mims, & Spooner, 2011; Vacc & Cannon, 1991); (b) Eight did not involve the implementation of a mathematical intervention (Allman, Pelphrey, & Meck, 2012; Banda, McAfee, Lee, & Kubina Jr, 2007; Chiang & Lin, 2007a; Donaldson & Zager, 2010; Gagnon, Mottron, Bherer, & Joanette, 2004; Legge, DeBar, & Alber-Morgan, 2010; Lloyd, Irwin, & Hertzman, 2009; Minshew, Siegel, Goldstein, & Weldy, 1994). Two additional studies that taught purchasing skills did not target money computation or value recognition of coins/bills (Gardill & Browder, 1995; Haring, Breen, Weiner, Kennedy, & Bednersh, 1995); and (c) Two studies did not provide data on a measure of mathematical skill: Banda and Kubina Jr. (2010) measured the latency between the time the student was given a non-preferred mathematical task and the time he started to work on it, and Fienup and Doepke (2008) measured the number of consecutive fluent responses to known mathematical questions within 3 seconds of the instruction.

Data extraction and coding

Studies that met the inclusion criteria were summarized in terms of the following features: (a) participant characteristics, (b) setting the intervention was conducted, (c) research design, (d) NCTM mathematical area(s) targeted, (e) specific mathematical skill taught, (f) the intervention used, (g) the procedural aspects of treatment fidelity, generalization and maintenance and (h) the study outcomes (i.e., effectiveness of the intervention as reported by the authors).

Finally, a more systematic evaluation of the methodological strength of the included studies was conducted based on the Scientific Merit Rating scale (SMRS) developed by the National Autism Center (2009). The SMRS is a scoring system designed to evaluate experimental rigour across five key dimensions: (a) Research design (i.e., the strength of experimental control); (b) Measurement of the dependent variable (i.e., accuracy and reliability of data collection); (c) Measurement of the independent variable (i.e., degree of procedural integrity); (d) Participant ascertainment (i.e., diagnosis provided by independent evaluators, using established diagnostic instruments); and (e) generalization of treatment effects (i.e., the degree to which intervention gains were maintained after the end of treatment and shown to generalize across settings, materials, and persons). Based on the scoring guidelines of the SMRS each study was given a score between zero and five on each of the five dimensions, with zero representing a weak and five a strong methodology; then a composite study score was calculated based on the following weighted formula (National Autism Center, 2009, pg 23): Research Design (.30) + Dependent Variable (.25) + Participant Ascertainment (.20) + Procedural Integrity (.15) + Generalization (.10).

Inter-rater reliability

To ensure the fit of the studies against the inclusion/exclusion criteria, an independent scorer coded the 33 studies that were selected after the initial search, by giving a "yes" or "no" code for each paper for each of the inclusion criteria. To calculate agreement, the total number of agreements was divided by the total number of agreements plus disagreements and multiplied by 100. There was a total agreement between the two scorers (100%).

Additionally, to ensure accurate evaluation of the methodological strength of the studies included in the present review, a second person trained in the use of the SMRS independently scored each of the 16 studies. The agreement between the two raters was r = 0.819 calculated by Pearson correlation on the composite score of each study.

Results

Of the 16 studies in the present review, fifteen used a single case experimental design and one a group design. The studies were published between 1988 and 2011, however the majority (n = 12) were published between 2008 and 2011. Only six of the 16 studies described mathematical interventions implemented exclusively with participants with an ASD diagnosis. The remaining ten studies either included some participants without autism (typically developing or with a different diagnosis) or targeted skills in other academic areas as well as one or more mathematical skills. Each of these two categories of studies is reported separately for ease of reference.

Mathematical Intervention Studies with Children with Autism

Participants and settings

Table 3.1 presents a summary of the six studies; all used a single case design. Participants were a total of 15 students, 9 male and 6 female. The age range of participants

Table 3.1

Summary of studies aiming to teach mathematics to children with autism

Study	Participants	Setting	Design	NCTM Mathematical area	Skill targeted	Intervention	Fidelity	Generalization/ maintenance	Results	SMRS score
Akmanoglu & Batu (2004)	n = 3 Chronological Age (CA) = 6, 12, 17	Special school	Multiple probe across behaviours	Numbers and Operations	Pointing to numerals named by teacher	Simultaneous prompting	Yes	Yes/ Yes	All participants acquired skill	3
Ault, Wolery, Gast, Munson Doyle & Elzenstat (1988)	n = 2 CA = 8	Special education classroom in elementary school	Parallel treatments design	Numbers and Operations	Answering "What number?" when presented with numeral card	Comparison of *constant time delay* and *system of least prompts* procedures	Yes	Yes/ Yes	Both procedures effective for the 2 participants, a 3rd participant (no details known) did not acquire any numbers	3
Cihak & Foust (2008)	n = 3 CA = 7-8	Special education classroom in elementary school	Alternate treatments design	Numbers and Operations	Solving single-digit addition problems	Comparison of *number lines* and *touch-point* strategies	Yes	Yes[1]/ No	Touch-points more effective for all three participants	4
Cihak & Grim (2008)	n = 4 CA =15-17	Special education classroom in high school, school bookstore, community settings	Multiple probe across behaviours and settings	Numbers and Operations	Independent purchasing skills: producing the correct amount of $ bills by counting-on	Use of a counting-on strategy	Yes	Yes/ Yes	All three participants acquired skill across settings and behaviours	4
Keintz, Miguel, Kao & Finn (2011)	n=2 CA = 6 yrs	Special education preschool classroom	Pre- post-tests	Measurement	Acquisition of untrained relations between coins and their values	Conditional discrimination training. Use of progressive time delay,	No	NA/ No	One participant acquired all untrained relations, one participant acquired 4/7	3

						reinforcement (tokens and praise)			untrained relations	
Rockwell, Griffin & Jones (2011)	n = 1 CA = 10	Home	Multiple probe across behaviours	Problem solving	Solving 1-step addition and subtraction word problems	Use of schematic diagrams corresponding to three types of word problems	Yes	Yes/ Yes	Participant met criterion for all three types of problems	3

[1] The generalization procedure did not include fading of the *touch point* prompts

was 6 to 17 years. Fourteen of the students had been diagnosed with autism and one with pervasive developmental disorder.

Five studies were conducted in a special education classroom; in one of these studies (Cihak & Grim, 2008) which targeted independent purchasing skills, two additional settings were used: the school bookstore, and a community shop. One study (Rockwell, Griffin, & Jones, 2011) was conducted at the participant's home, during the summer vacation.

Research design and measures

A multiple probe design was used in three of the studies, two studies used an alternating treatments design, and one study used an A-B single case design (Keintz, Miguel, Kao, & Finn, 2011). The dependent measure used in five studies was the percentage of correct responses. One study (Rockwell et al., 2011) used a point scoring system with three points being the maximum score for each problem. Correctly solving of each component of the problem earned the student a point.

Mathematical areas and skills targeted

The content area of Numbers and Operations was targeted in four studies and the specific skills taught included identification of numerals (2 studies: Akmanoglou & Batu, 2004; Ault, Wolery, Gast, Munson Doyle, & Eizenstat, 1988), single-digit addition solving (1 study, Cihak & Foust, 2008), and counting-on strategies (1 study, Cihak & Grim, 2008). Correspondence between coins and their values, from the content area of Measurement was taught in one study (Keintz et al., 2011). The process area of Problem solving was targeted in the sixth study by Rockwell et al. (2011) who taught a strategy for solving addition and subtraction word problems.

Instructional methods and outcomes

In two of the studies, the independent variable was the prompting method(s) used to teach the specific mathematical skill. Akmanoglou and Batu (2004) used simultaneous prompting. With this prompting method the teacher consistently provides a prompt together with the instruction during the training sessions. Thus an erroneous response is prevented. Acquisition of the skill is assessed during separate sessions (probes) where the task is presented without the controlling prompt. Findings showed the intervention to be effective across three students of different ages.

Ault et al. (1988) compared two prompting methods: constant time delay, and a system of least prompts (also known as least-to-most prompts). During the constant time delay procedure, the teacher presents the task and waits for a fixed interval (e.g., 3 seconds) before providing a prompt to the student. With the system of least prompts, initially the instruction is given without any prompt; if the student does not respond or gives an erroneous response, the least intrusive prompt is provided. If again the student cannot respond correctly, the next prompt within the least-to-most prompt hierarchy is provided until the student gives a correct response. Results indicated that both procedures were equally effective for the two participants. However, constant time delay resulted in faster acquisition of skills. The investigators briefly reported that a third participant did not learn any numerals with either procedure.

In the third study (Cihak & Foust, 2008), the effectiveness of two different teaching materials to teach single-digit addition were compared. The authors used: (a) a number line, a ruler-like object containing numerals 0 to 20, and (b) touch-points, numerals with dots on them (the number of dots correspond, to each numeral, e.g., 1 had one dot, 2 two dots). The study outcomes showed touch points to be the more effective strategy. The three students acquired the target skill when this teaching method was used, whereas the number line strategy was effective but at a slower rate of skill acquisition with one child, partially effective with the second, and ineffective with the third student.

In the study by Cihak and Grim (2008), students were taught independent purchasing using the correct amount in US dollar bills. The following skills were trained: (a) choosing the correct first bill with a value that corresponded to the price of the item (e.g., a $5 bill for an item priced $9), and (b) counting-on by ones from the value of this bill as they added one-dollar bills up to the correct amount they need (e.g., say “5-6-7-8-9” as they count out the amount of $9). The four students who participated in this study acquired the target skill. A strength of this study was the fact that the intervention was conducted across three different settings (i.e., the students’ classroom, the school bookstore, and a community shop).

In the study by Keintz et al. (2011), the researchers trained three relations between coins and their values (i.e., spoken coin name – printed value, printed value – actual coin, spoken value – actual coin) and evaluated whether the students would acquire untrained relations (e.g., spoken coin name – actual coin, actual coin – printed value, spoken value – printed value). Procedures included a progressive time delay prompting system. For new tasks initially a prompt was given at the same time as the instruction (i.e., 0 seconds of delay), then as the student became familiar with the task, the interval between the instruction and the delivery of the prompt was gradually increased (1 sec., 2 sec., 3 sec., 4 sec., 5 sec., etc.). Additionally, two levels of reinforcement were employed: independent correct responses were reinforced with a token (tokens were later exchanged for a favourite activity), whereas prompted correct responses were reinforced with. The intervention was effective for one participant who after being taught on the three first relations acquired all seven untrained relations. Results of the second participant indicated partial success as he acquired four of the seven untrained relations.

The sixth study (Rockwell et al., 2011), targeted teaching a student a strategy for solving different types of word problems which included the following steps: (a) read the problem, (b) make a diagram corresponding to the problem type, (c) write the number sentence, and (d) state the answer. The main instructional component was that the student was taught to create a schematic diagram that helped her identify the correct operation (addition/subtraction) needed to solve the problem. Data indicated that the intervention was effective across the three categories of word problems.

Methodological quality

As shown on Table 3.1, out of a maximum score of 5 on the SMRS scale (National Autism Center, 2009), two studies were given a score of 4 and four studies were given a score of 3. According to the SMRS guidelines a score of at least 3 points indicates a sufficient methodological quality that allows for firm conclusions about the effects of the intervention.

Studies Focused on Mixed Participant Groups and/or Mixed Academic Skills

Participants and settings

A summary of the studies that either included participants without autism or taught non-mathematical as well as mathematical skills is presented in Table 3.2. Ninety three students in total participated in 9 single case design and one group design studies. Of these, forty students with ASD received teaching on at least one mathematical skill. Across the studies, 12 of the ASD participants had a diagnosis of autism, 25 were diagnosed with high functioning autism, two with asperger syndrome, and one with PDD-NOS. Ages of the ASD students ranged between preschool (no chronological age specified) and 16 years of age. Six of the studies were conducted in a special needs classroom and two studies took place in a regular education classroom. One study was conducted in a separate room off the main

Table 3.2

Summary of studies including participants without autism and/or non-mathematical targets

Study	Participants	Setting	Design	NCTM Mathematical area	Skills targeted/ Mathematical skill taught	Intervention	Fidelity	Generalization/ maintenance	Results	SMRS score
Adcock & Cuvo (2009)	3 w/ an ASD (1 w/ autism, 1 w/ Asperger, 1 w/ PDD-NOS) Chronological Age (CA) = 7 - 10	Therapy room in regular education elementary school	Multiple probe across behaviours	Numbers and Operations, Measurement	Increasing performance in various tasks (mathematics, language, following instructions). Addition, subtraction, multiplication, telling time, value of coins (child specific tasks)	Preference assessment, token economy, most-to least prompts, interspersal of maintenance tasks among acquisition tasks	No	No/ No	All participants met criterion across all different skills	3
Collins, Hager & Galloway (2011)	3 w/ moderate disabilities (including 1 w/ autism) CA = 14 yrs	Special education resource room in middle school	Multiple probe across behaviours	Numbers and Operations	Increasing performance in language, science and mathematical tasks. Computing price of items with tax using a calculator	Addition of functional content (e.g. using pictures of items from advertisements)	Yes	Yes/ No	Procedure partially effective, ineffective for mathematical skill of participant w/ autism	3
Fletcher, Boon & Cihak (2010)	3 w/ moderate intellectual disabilities (including 2 w/ autism) CA = 13 -14 yrs	Special education classroom	Alternate treatments design	Numbers and Operations	Solving single-digit addition problems	Comparison of *number lines* and *touch-point* strategies	Yes	Yes[1]/ No	Touch-points more effective for all participants	4
Holifield, Goodman, Hazelkorn & Heflin (2010)	2 w/ autism CA = 9 – 10 yrs	Autism classroom in elementary school	Multiple probe across participants	Numbers and Operations	Increasing attending to task and academic accuracy (Solving 1-digit multiplication /subtraction without regrouping problems)	Self-monitoring procedure	No	NA/ No	Attending to task and accuracy increased for both participants	2

Kamps, Locke, Delquadri & Hall (1989)	2 w/ autism CA = 9, 11 yrs	Special education classroom	Multiple probe across behaviours	Measurement, Numbers and Operations	Increasing mathematical, language and reading skills. Coin identification, value of individual coins and coin combinations	Typically developing peers as tutors	Yes	No/ No	Increase of correct responding for both participants	2
Leaf, Sheldon & Sherman (2010)	3 w/ autism Mathematics: n = 1 CA = 5 yrs	Research setting	Parallel treatments design	Numbers and Operations	Two- choice discriminating learning: discrimination between 2 sums, e.g. “touch 1+3”	Comparison of *simultaneous prompting* and *no-no prompting* procedures	Yes	No/ Yes	No-no prompting a more effective procedure for all participants and skills	4
Levingston, Neef & Cihon (2009)	1 w/ autism and 1 typically developing CA = 10	Regular education classroom	Multiple probe across behaviours	Problem solving	Solving 1-step multiplication and division word problems	Teaching four pre-requisite skills (identification of label, operation, larger number, smaller number)	Yes	Yes/ No	Performance increased for both participants	4
Polychronis, McDonnell, Johnson, Riesen & Jameson (2004)	4 w/ developmental disabilities, including 2 w/ autism. Mathematics: n = 1 CA = 7	Regular education classroom	Alternate treatments design	Measurement	Academic skills (mathematics, social studies). Telling time at 15 minutes and 30 minutes past the hour	Comparison of 30-minute and 120-minute distribution trial schedules of embedded instruction using constant-time-delay and reinforcement (praise)	Yes	Yes/ No	Both schedules were effective	4
Su, Lai & Rivera 2010	2 groups (intervention and control) with 34 in each group (including 25 w/ high-functioning	2 preschool classes for children with autism, 2 integrated preschool	Control group pre-post- test	Comprehensive mathematic instruction	Evaluation of the Project MIND for children with autism	Direct and embedded instruction based on the Project MIND	No	No/ No	Significant improvements of intervention group at post-test (no separate data for children with autism). Children w/ autism in	2

	autism) CA = preschool age	classes							intervention group improved significantly at mathematical reasoning and problem-solving at post-test	
Waters & Boon (2011)	3 w/ mild intellectual disabilities (including 1 w/ autism and 1 w/ Asperger) CA = 15 – 16 yrs	Special education classroom in high school	Multiple probe across participant s	Numbers and Operations	Solving 3-digit money subtraction problems with regrouping	Use of *touch-point* strategy	Yes	Yes[1]/ Yes	Intervention effective for both participants. A third participant without autism did not maintain his gains	3

[1] The generalization procedure did not include fading of the *touch point* prompts

regular education classroom (Adcock & Cuvo, 2009) with participants who were fully integrated in the regular education classroom, and one study was conducted in a research setting (Leaf, Sheldon, & Sherman, 2010).

Research design and measures

A multiple probe design across participants or behaviours was used in six studies and an alternating treatments design was used in three studies. A quasi-experimental controlled design was used in the tenth study (Su, Lai, & Rivera, 2010).

In eight of the 10 studies the dependent measure was the percentage of correct responses. In another study (Kamps, Locke, Delquadri, & Hall, 1989) a variation of the same measure was used: instead of a percentage, the number of correct responses (e.g., x correct responses out of 18 questions asked) was presented. Finally, in the Su et al. (2010) group design study the mathematical reasoning and problem-solving subtests from the Hawaii Early Learning Profile (HELP, Parks, 1992) and the Bracken Basic Concept Scale – Revised (1998) were used.

Mathematical areas and skills targeted

In seven of the 10 studies the following skills from the area of Numbers and Operations were taught: number identification (Leaf et al., 2010), solving addition problems (Adcock & Cuvo, 2009; Fletcher, Boon, & Cihak, 2010; Kamps et al., 1989), solving subtraction problems (Adcock & Cuvo, 2009; Holifield, Goodman, Hazelkorn, & Heflin, 2010; Waters & Boon, 2011), and solving multiplication problems (Adcock & Cuvo, 2009; Collins, Hager, & Galloway, 2011; Holifield et al., 2010). One study targeted the skills of coin identification and coin value recognition from the content area of Measurement (Kamps et al., 1989). Recognising time, another Measurement skill, was targeted in two studies

(Adcock & Cuvo, 2009; Polychronis, McDonnell, Johnson, Riesen, & Jameson, 2004). One study (Levingston, Neef, & Cihon, 2009) taught solution of multiplication and division word problems, a skill from the area of Problem solving. Finally, one study targeted comprehensive instruction with the use of a mathematical curriculum (Su et al., 2010).

Instructional methods and outcomes

Leaf et al. (2010) compared two response prompting methods, simultaneous prompting and no-no prompting. With simultaneous prompting, a prompt is provided simultaneously with the instruction to the student (see also previous section on studies included in Table 4.1). With no-no prompting on the other hand, the teacher initially gives the student two opportunities to respond independently, then, in the case of two consecutive erroneous responses, provides a prompt during the third presentation of the task. Findings indicated that the latter procedure was more effective. The participant acquired all the target skills taught with no-no prompting and one out of four skills taught with simultaneous prompting.

Number lines and touch points were two strategies used by Fletcher et al. (2010) to teach addition tasks, similar to the study by Cihak and Foust (2008) in the previous section of this review. Results showed touch points to be a more effective strategy than the number line. The touch point strategy was also used in the Waters & Boon (2011) study to teach subtraction skills to two students with ASD enrolled in a special education high school class , and results were positive.

In the Adcock & Cuvo study (2009), conducted with students enrolled in a regular education class, the intervention consisted of a package of behavioural procedures which included: (a) Conducting preference assessments to identify favourite items for each child; (b) Reinforcing correct responding on acquisition tasks using tokens which were exchanged for preferred items at the end of the session; (c) Most-to-least prompting procedures: following an erroneous response, with the next presentation of the task the teacher provided a full prompt then during consecutive trials less intrusive prompts were used; and (d) Interspersing easier, previously acquired tasks between acquisition tasks. Implementation of these procedures resulted in immediate improvements (i.e., the graphs indicated that there were no overlapping data points between baseline and treatment phases) across students (n=3) and tasks (addition, subtraction, multiplication, recognising coin values, telling time).

In the study by Polychronis et al. (2004), conducted with a student with autism who attended a regular education class, embedded instruction was the method used. This is a procedure that involves distributing instructional trials during other ongoing academic activities. For example, during a literacy lesson with the whole class, the teacher may conduct three short individualised teaching sessions with the student with autism. In this study, two distribution schedules, a 30-minute and a 120-minute schedule, were compared. Instructional procedures used during both schedules included: (a) a constant time-delay prompting strategy, and (b) social reinforcement in the form of praise. Results indicated that both schedules were equally effective. The student acquired both sets of skills, and there was no difference between the two schedules in the number of sessions needed to reach mastery.

A self-monitoring procedure aiming to increase attending to task and academic accuracy was the method used by Holifield et al. (2010). The students were taught to record on a self-monitoring sheet whether or not they were attending to their assigned work when the teacher gave them a cue to do so. Results indicated that accuracy levels of both students reached criterion. A weakness of this study was some missing baseline data on one of the two participants and a very high (Mathematical accuracy = 100%) last baseline data point for the same student.

Kamps et al. (1989) implemented an intervention involving using typically developing peers as tutors of the children with autism. Tutors received group and individualised training, supervision, and feedback from the class teacher. The intervention resulted in an increase of accurate responding for both participants.

In the Collins et al. (2011) study, intervention consisted of using additional, real-life stimuli during mathematical instruction. The target skill was calculating the final price of items by computing and adding tax. To make the task more applied, pictures of items from advertisements were given to the student as additional stimuli. There was no improvement in the student's performance as a result of this addition.

To increase performance in solving word problems that involved multiplication and division operations, Levingston et al. (2009) taught the student four pre-requisite skills: (a) labelling the task he had to solve, (b) identifying the operation he needed to perform (multiplication or division), (c) identifying the largest number of the problem, and (d) identifying the smallest number. Teaching the first three pre-requisite skills to a mastery level resulted in acquisition of the fourth skill (identification of the smallest number) and in an increase of accurate problem solving.

In Su et al. (2010) which was the only study that used a group design, children of the intervention group received mathematical instruction based on the Project MIND (Maths is not difficult, Su, 2002). Although the main aim of this study was to evaluate the use of Project MIND with young children with autism, we were unable to use the between-groups data in the present review as a number of typically developing children participated in each group and data of the participants with autism were not analyzed separately. However, the authors conducted a separate pre- post analysis of the data of participants with ASD in the intervention group only, which showed a statistically significant improvement on one of the tests, the Hawaii Early Learning Profile (Parks, 1992). There was no description of the instruction children in the control group received.

Methodological quality

For the studies in this category, the design field of the quality system was rated on the basis of the overall study design (i.e., all participants, not just the ones with a diagnosis of autism, and comparisons across all targeted skills, not just mathematical skills). Out of a maximum score of 5, four studies were given a rate of 4, four studies were given a rate of 3, and two studies were given a rate of 2. Scores of 3 or more indicate sufficient methodological quality and allow for firm conclusions regarding effects of an intervention. A score of 2 on the other hand, indicates some initial evidence regarding intervention effects but additional research of a higher methodological quality should be conducted before firm conclusions can be drawn.

Discussion

A systematic search of the literature yielded 16 studies that focused on teaching mathematical skills to students with ASD. Not all NCTM mathematical content areas were represented in the reviewed studies. The area of Numbers and Operations was targeted in the majority (n=11) of the studies. A few of the studies targeted the basic skill of numeral identification. However, in most of the reviewed studies (n=8), the more advanced skills of arithmetic operations were taught (i.e., addition, subtraction, multiplication, and division). Other skills targeted included time and money skills from the content area of Measurement (n=4) and solving word problems from the process area of Problem Solving (n=2). We did not find any studies that taught skills from the content areas of Algebra, Geometry, or Data Analysis and Probability (NCTM, 2000). Similar findings were reported by Browder et al. (2008) in their meta-analysis on teaching mathematics to individuals with significant cognitive disabilities: the majority of research focused on Number and Operations and Measurement skills.

In seven of the 16 studies the intervention consisted of an Applied Behaviour Analysis (ABA) strategy (e.g., a prompting strategy) or a “package” of strategies (e.g., a prompting method and a system of reinforcement). Prompting strategies evaluated included simultaneous prompting (Akmanoglou & Batu, 2004; Leaf et al., 2010), constant time delay, system of least prompts (Ault et al., 1988), and no-no prompting (Leaf et al., 2010). Conflicting results were found by the two studies that evaluated simultaneous prompting to teach identification of numerals: Akmanoglou and Batu (2004) found the method to be effective with three participants, whereas Leaf et al. (2010), who compared this method with no-no prompting, found that the participant acquired only one of the four skills taught with the simultaneous prompting method. The results of the Leaf et al. (2010) study indicated that no-no prompting was a more effective method. It is difficult to draw any conclusions on the most effective prompting method to teach mathematical skills based on the existing evidence. Generally, the consensus among behaviour analysts with regard to choosing the most appropriate prompting methodologies is that decisions should be based on students’ learning profiles and the specific task to be taught (Miltenberger, 2008).

Two studies evaluated a “package” of ABA based procedures in the context of a regular education classroom. Adcock and Cuvo (2009) implemented a model normally used in individualized intervention programs with children with ASD consisting of preference assessments, use of token systems, a most-to-least prompting strategy, and interspersal of easier, previously acquired tasks among the current targets on which the child was working. Because a teaching aide supported each child, conducting daily individualized sessions in an area off the main classroom was a viable option. The number of sessions that participants needed to acquire a mathematical skill ranged between 6 and 8 and duration of sessions was 20 minutes.

A less intensive model of embedded instruction was used by Polychronis et al. (2004), also with a student with ASD enrolled in a regular education classroom. With this model the student remained in the main classroom and during a lesson with the whole class the teacher conducted an average number of four individualized teaching trials with the child with ASD and duration of lessons was either 30 or 120 minutes. However, the number of individualized trials remained the same. Procedures used included a constant time delay prompting strategy and reinforcement in the form of praise. The student acquired the target skills after four daily sessions of embedded instruction.

Another study that used a behavioural “package” in the context of a special needs preschool classroom was the project by Keintz et al. (2011).Preference assessments, token economies, and a progressive time delay prompting system were the procedures used. Self-monitoring was another ABA based strategy that was used by Holifield et al. (2010) to increase attending to task. Academic accuracy in mathematical tasks increased as a result of the intervention.

The ABA teaching methodologies used in the studies reviewed in the present paper have been used with children with ASD for decades, and have been shown to be effective in teaching a variety of academic and non-academic skills. However, the small amount of research and the variety of methodologies used in the studies included in the present review allow for only tentative conclusions about mathematics instruction. Reviews of the literature on teaching mathematics with other populations with disabilities tend to conclude in favour of ABA strategies. For example, the main conclusion of the Browder et al. (2008) meta-analysis was the importance of using strategies that included explicit prompt fading strategies.

In six of the studies, the intervention involved teaching the students with ASD a specific mathematical strategy or a set of mathematical skills. Skills and strategies evaluated included: (a) using number lines and touch-points to solve additions and subtractions (Cihak & Foust, 2008; Fletcher et al., 2010; Waters & Boon, 2011), (b) using a counting-on strategy (Cihak & Grim, 2008), (c) making a diagram that represented the type of word problem the student needed to solve (Rockwell et al., 2011), and (d) a set of four prerequisite skills that helped the student solve word multiplication and division problems (identifying the label of the problem, the operation they needed to perform, the larger of the two numbers involved, and the smaller of the two numbers) (Levingston et al., 2009). Positive results were reported in all studies. However, for most of the interventions it is difficult to draw solid conclusions as the existing evidence is limited. The only mathematical strategy that was evaluated in three different studies was the use of touch-points to solve additions and subtractions.

Other interventions implemented included training typically developing peers to tutor their classmates with ASD (Kamps et al., 1989), and using pictures of items for sale when teaching tax computation (Collins et al., 2011). The latter intervention did not increase the student's accuracy.

A limitation of the present review is that many of the included studies did not exclusively include students with ASD. There is a possibility that other, similar studies involving mixed samples might have been published which were not identified by our search strategy.

According to a classification system developed by the National Autism Center (National Standards Report, 2009) to help determine the strength of evidence of interventions implemented with persons with ASD, an intervention can be classified as *established*, *emerging*, *unestablished*, or *ineffective*. An *established* intervention must be supported by: (a) a minimum of 2 group design or 4 single subject design published studies that include at least 12 participants; (b) the studies should have a score of 3, 4, or 5 on the SMRS; (c) results of all studies are positive. An *emerging* intervention should be supported by: (a) a minimum of 1 group design or 2 single subject studies that include at least 6 participants, (b) scores of 2 on the SMRS, and (c) positive results. Based on these criteria, the only mathematical intervention included in the present review that exceeds the emerging level of evidence is the use of the touch-point strategy to solve additions and subtractions. The three studies which evaluated this intervention included a total of seven students with ASD (Cihak & Foust, 2008; Fletcher et al., 2010; Waters & Boon, 2011). Two of the studies have a score of 4 and one a score of 3 on the SMRS, and results for all participants were positive. Despite the fact that further research is necessary before the touch-points strategy can be deemed as an established intervention, the existing evidence is promising.

In two of the studies the touch-point strategy was compared to that of using a number line (Cihak & Foust, 2008; Fletcher et al., 2010). Comparisons of the touch-point method to different strategies should be a focus of future research. From a developmental point of view, solving an additive task using a number line demands a higher level of mathematical competence than using touch-points. When working with the number line, the student uses a counting-on strategy. If he is working to solve the 4 + 3 problem for example, he needs to find the number 4 on the number line, and then count-on 3 more numbers (i.e., says “4-5-6-7”). When solving the same task using touch-points, the student starts counting from 1; he first counts the touch-points of the first numeral (“1-2-3-4”) and he then counts the touch-points of the second numeral (i.e., says “5-6-7”). Steffe (1992) who conducted extensive research on early number acquisition, identified certain learning stages in children’s progress:

in the *perceptual* stage the child needs to see (i.e., perceive) the collection of items he counts; in the *figurative* stage he can visualise a collection even if the items are not visible. According to this model, the touch-point strategy where the child can see, touch, and count each point one-by-one can be approached by a child whose numeral knowledge is at the perceptual level. To solve the same task using a number line, however, he needs to be able to work at the figurative level.

A point that seems to have received limited attention within the existing research is the development of structured, comprehensive curricula, appropriate for students with ASD. Possibly one of the reasons that certain mathematical areas identified by the NCTM (2000) do not seem to be taught to students with ASD (e.g., Geometry and Algebra) is the lack of corresponding curricula. We only found one study that evaluated a mathematical curriculum rather than an isolated mathematical skill (project MIND, Su et al., 2010). This curriculum was implemented with pre-school age children, and there was no information regarding its suitability for older students with ASD. The availability of curricula that are organized into progressive levels of mathematical skills would help teachers of students with ASD better identify the current level of each child's mathematical abilities and then choose the most appropriate target skills they need to teach. The combination of comprehensive curriculum guides with effective teaching methodologies would benefit students with ASD and the teaching professionals who work with them.

Chapter 4. An Individualized Curriculum to Teach Numeracy Skills to Children with Autism: Program Description and Pilot Data[2]

[2] The following persons contributed to the empirical study described in this chapter and will, at times, be referred to as co-authors: Corinna Grindle, Maria Saville, Richard Hastings, Carl Hughes and Kathleen Huxley

Abstract

Teaching mathematics to children with autism is an area with limited research evidence. In this study we developed a teaching manual based on Maths Recovery, a numeracy program designed for typically developing children. Six children with autism enrolled in an Applied Behaviour Analysis (ABA) school setting participated in the study and received daily numeracy teaching over a 20-week period. Our aims were to explore whether Maths Recovery can be used as a numeracy curriculum for children with autism, evaluate the progress the children make after a period of intensive teaching, and check for maintenance of numeracy improvements after the end of the intervention. Using a pre-test post-test design we found that the adapted Maths Recovery numeracy curriculum was successfully incorporated within each child's individualized teaching program, and that all six children improved their mathematical ability over the course of the intervention. The five month follow up data showed differences among children, with some of them maintaining their previous gains while others had a decline. Our data show promising results and support the rationale for larger evaluation studies.

Within the research literature on interventions with children with autism, investigating the best methods of teaching mathematics has received limited attention (Su et al., 2010). Most existing research has focused on the acquisition of a specific mathematical skill. For example, receptive identification of numerals was targeted by Akmanoglou and Batu (2004) who used an errorless teaching method, simultaneous pointing, with three students with autism aged between 6 and 17. Cihak and Foust (2008) compared two different strategies for teaching single-digit addition to three elementary school children with autism. The first involved the use of a number line 1-20; the child found the number representing the first addend and then moved on for as many numbers as the second addend to find the addition result. The second strategy employed “touch points”, numerals that have dots on them (one dot for 1, two for 2, etc). To solve the addition problem the child was instructed to count aloud the dots of the two addends and then write the last number he/she had said. Touch points was shown to be a more effective method for all participants. In another recent study, a 10-year-old girl with autism was taught to solve different types of math-word problems involving addition and subtraction by using schematic diagrams (Rockwell et al., 2011). Levingston, Neef, and Cihon (2009) explored multiplication and division word problem solving with two participants one of whom had autism. They found that systematic instruction on four prerequisite skills (identifying the label of the problem, the operation they needed to perform, smaller numbers, and larger numbers) resulted in increased correct problem solving.

One conclusion that can be drawn from this limited literature is that children with autism can learn isolated mathematics skills. Achieving mathematical competence, however, involves not just the mastery of a few isolated skills, but a combination of many separate repertoires. It is important that individual skills be taught systematically as components of a comprehensive mathematics program (Browder et al., 2008).

There is a similar paucity of information and research on how to teach mathematics in curricula described in the autism-focused early intensive behavioural intervention (EIBI) literature. A number of teaching manuals based on the principles of Applied Behaviour Analysis (ABA) have been developed to help professionals working with children with autism systematically teach an array of essential skills (Leaf & McEachin, 1999; Lovaas, 2003; Maurice et al., 1996; Sundberg, 2008). In these guides, considerable emphasis is placed on aspects of language development, such as understanding receptive instructions, requesting, using progressively more complex sentences, answering questions, using pronouns, and prepositions, to name a few. "Learning how to learn" skills (e.g., attending skills, imitation, compliance with instructions) are also a priority. In the academics area there are generally more programs targeting reading compared to mathematics (e.g., 6 reading and 2 math targets in the Advanced Curriculum Guide in Maurice et al., 1996). Program descriptions for listed targets are brief (e.g., 20 math targets presented within 2 and a half pages in Leaf & McEachin, 1999). Given the complexity of repertoires required to be competent at mathematics, a more detailed and systematic teaching tool is needed to help professionals provide effective mathematics instruction to young children with autism.

One of the key areas in early mathematics is numeracy, or "number and operations" as identified by the National Council of Teachers of Mathematics (2000). This refers to the ability to understand and represent numbers, relationships among numbers (place value), and number operations (addition, subtraction, multiplication, and division). Because numeracy skills play a significant role in aspects of everyday life such as shopping and managing one's finances (Patton, Cronin, Basset, & Koppel, 1997), the question of how best to teach these skills to children with autism is practically significant.

We concentrated on five criteria in choosing a numeracy curriculum to use and evaluate, and the Maths Recovery program (Wright, Martland, Stafford, & Stanger, 2006a) met all of these criteria. First, the program is designed for young children at the first years of school, so it is suitable even for a child with no numeracy skills. Second, its development has been informed by extensive research on how children construct numerical knowledge. Third, existing data on the program's use with typically developing children, show it to be effective. Fourth, it is designed for individualized teaching and therefore adaptable to each child's needs. Finally, there are common elements with ABA programs that would facilitate compatibility with ABA teaching methods so that it could be used in early intervention and early school-based programs for children with autism. For example teaching strategies like "micro-adjusting" and "scaffolding" (Wright et al., 2006a , p. 31) are functionally similar to shaping and prompting/prompt-fading. In addition, most individual teaching activities are divided into smaller, progressive steps much in the same way as task analysis is used in ABA programs to break complex skills into teachable units.

Maths Recovery: Description and existing evidence

Maths Recovery was developed in Australia in the 1990s (Wright, Cowper, Stafford, Stanger, & Stewart, 1994; Wright et al., 2006a), and was intended as a tool for intensive, individualized numeracy teaching for children in mainstream classrooms who after their first year in school demonstrated low attainment. The curriculum is divided into five stages with progressive levels of sophistication: 1. Emergent (the child has few counting skills). 2. Perceptual (the child can count and do some additive tasks when objects are visible). 3. Figurative (the child can do additions but, although both quantities are known, the child still starts counting from one). 4. Counting-on (the child can use counting-on for additive tasks and counting-back to subtract). 5. Facile (the child can use more advanced strategies rather than counting-by-ones, such as incrementing and decrementing by tens). Activities for each stage are grouped into areas called Key topics. For example, the Emergent stage includes the following Key topics: (a) Number word sequences 1-20, (b) Numerals 1-10, (c) Counting up to 20 visible items, (d) Spatial patterns (recognising patterns on cards without counting), (e) Finger patterns (different ways of counting using one's own fingers) , and (f) Temporal patterns and temporal sequences (copying and counting patterns of sounds and movements). Each Key topic includes 3-10 individualized programs. In the Numerals 1-10 Key topic for example, the child is taught to expressively identify a number on a number card, read number lines forwards and backwards, place number cards in order, receptively identify numbers presented in random order, and so on.

The intervention procedure for typically developing children involves the following steps: 1. A trained teacher conducts an individualised assessment interview with the student to determine his current numeracy stage. 2. Based on the assessment results, activities from different Key topics that will help advance the student's strategies are selected. 3. The student is taught intensively on an individual basis for 30 minutes a day, 4-5 times a week, for approximately 12 - 15 weeks. 4. At the end of the intervention period the assessment interview is repeated. The student then resumes group mathematics instruction with the rest of his class.

Data from Australian schools (Wright et al., 1994; Wright, 2003), and from other parts of the world where the program has been implemented, show positive results. In UK research, 210 low-attaining students received individualised teaching for 20 half-hour sessions, 3 or 4 times a week (Willey, Holliday, & Martland, 2007). Pre- and post-test data based on the Maths Recovery assessment tools showed that after intervention 48% of the participants had gained 2 arithmetic stages, 27% 1 stage, 15% 3 stages, and 6% had remained at the same stage although they had improved their numeracy skills. A more recent study conducted in 20 elementary schools in the USA (Smith et al., 2010), was the first Maths Recovery evaluation study to include a standardised mathematics test in addition to the program assessment tools. In this project, 343 first-grade students received 30 minutes of daily instruction for 4-5 times a week for approximately 11 weeks. A waiting list control design was used. Significant effects of teaching with Maths Recovery were found, with small effects (Cohen's d = .26) on the numeracy subtests of the Woodcock Johnson III (2001) and large effects (Cohen's d = .85) on the Maths Recovery assessment test.

In addition to its use as an individualised intervention tool, Maths Recovery has been used as a model for whole classroom teaching with typical learners. The "Count Me in Too" numeracy program which has been successfully implemented in hundreds of Australian and New Zealand primary schools (Bobis et al., 2005) is an adaptation of Maths Recovery, also developed by Wright (2003). Practitioners in other countries including the USA and the UK have adopted the model. A strong emphasis is placed on the importance of conducting continuous assessments of the students' current level of sophistication to the end that teaching will be focused "just beyond the cutting-edge" of the children's knowledge (p.6, Wright, Martland, & Stafford, 2006b).

The primary aim of the present study was to investigate the feasibility of adapting Maths Recovery for use with children with autism. We developed a detailed teaching manual (see Appendix 6) to ensure fidelity of teaching and systematic instructional procedures were followed with all children. The second aim was to investigate whether intensive individualized teaching using Maths Recovery would improve the numeracy skills of young children with autism. A third exploratory aim was to investigate whether any gains the children made after intervention would be maintained over time.

Method

Participants

Six boys participated in the study. All had a clinical diagnosis of autism and attended an autism unit attached to a mainstream school in the UK. This educational provision offered intensive behavioural intervention based on the principles of ABA (for a description of the educational model see Grindle et al. 2009; 2012). Their ages at the beginning of the study ranged between 47 and 81 months (M= 65.67 months, SD= 13.26). Two of the children (Elias and Liam) were new students in the unit at the time the study began, whereas the rest of the children had been enrolled for a longer period (e.g., Malcolm and Stuart, a little over 2 years). To be eligible to participate in the study the children had to be performing below the level expected for their chronological age in mathematics and to have the following prerequisite skills: Sitting willingly at a table to engage in learning tasks for short periods of time (up to 15 minutes), following simple one-step instructions (e.g., “clap hands”), matching and sorting of pictures and number cards, and receptive and expressive labelling of at least 50 objects and pictures. In addition, so that verbal and motor prompts could be utilized throughout teaching, the children had to be able to repeat back simple words that they heard (i.e., have an echoic repertoire) and be able to imitate gross and fine motor movements.

At the start of the study, all six children had some verbal abilities although individual levels varied and ranged from a using a few single words to talking in full sentences. Integration in mainstream school was part of the individual program for four of the children whereas two children did not have integration time at the time of the study; Liam found transitions to different settings especially difficult and Mike did not have the prerequisite skills that would have enabled him to benefit from participating in that setting.

As part of the ongoing annual assessments taking place in the unit (Grindle et al., 2012), all students were assessed for IQ and Adaptive Behaviour. The tests were conducted approximately six months prior to the beginning of the study. Five of the children were tested on the Stanford-Binet Intelligence Scale-Fourth Edition (Thorndike et al., 1986). Mike was tested on the non-verbal Leiter International Performance Scale-Revised (Leiter-R, Roid & Miller, 1997) because he did not have the verbal skills to be able to fully understand the Stanford-Binet. Adaptive behaviours were assessed using the Vineland Adaptive Behaviour Scales II (Sparrow et al., 2005).

Information on the ages, standardized test scores, and individual characteristics of the six boys participating in the study is presented in Table 4.1.

Setting

For five of the six students, all teaching sessions were conducted at the child's individual work area, typically consisting of a table and two chairs, a variety of teaching materials, and a collection of favourite toys and books for short breaks between teaching sessions. For the first 10 weeks of the intervention, Malcolm also received his Maths Recovery teaching sessions at his individual work area in the autism unit. However, after this time, he received a combination of one-to-one teaching sessions in the autism unit and group math teaching using Maths Recovery in the mainstream classroom. Maths Recovery was also the numeracy curriculum used by teachers in the mainstream school and Malcolm had two 20-minute lessons per week in that setting with his typically developing peers. The setting was changed for Malcolm because his success at meeting mainstream integration targets meant that that by the end of the study he was in mainstream school for most of the day.

Table 4.1

Participant characteristics

Child	Age at pre-test (in months)	IQ score	VABS Composite	Verbal repertoire	Time in ABA class (in months)	Mainstream integration targets
Elias	47	83	68	Sentences ≤ 3 words	2	20-40 minutes/day
Aaron	59	61	62	Echolalic words/phrases	14	1 hour/week
Liam	62	77	57	Sentences ≤ 3 words	2	none
Stuart	64	89	74	Sentences ≥ 4 words	14	20-40 minutes/day
Mike	81	51 (Leiter-R)	56	Single words	26	none
Malcolm	81	93	79	Sentences ≥ 4 words	26	2-4 hours/day

Materials

Maths Recovery teaching manual – Autism version. To help promote a systematic approach to teaching numeracy to children with autism, we developed a teaching manual based on the book *Teaching Number* by R. J. Wright et al., (2006a). In keeping with ABA methodology, for each skill mentioned in the book we:

1. Clearly specified the goals for learning so that they would be observable and measurable. We also described a mastery criterion as a way of objectively determining whether the goal had been achieved.

2. Because children with autism do not always easily generalize skills taught, we added a generalization step to every program to ensure the child could be successful with the task in different environments, with a variety of materials, or a different teacher.

3. Conducted task analyses on the more complex skills (i.e., we broke down complex skills into smaller steps for learning).

4. Suggested a systematic approach to instruction by: (a) shortening verbal instructions and specifying wording for teachers and, (b) including prompting and prompt-fading instructions for each step of the target skill.

A sample lesson plan is presented in Appendix 6.

Teaching Materials. We used a variety of materials that are part of the Maths Recovery curriculum, such as counters of different colours, number-lines (1-5, 1-10, 11 – 15, etc), numeral tracks (number-lines with a small cover for each numeral), number cards for individual numbers, domino cards with 1-6 dots, and cards with 1-4 dots in irregular patterns. We created some of these (e.g., numeral tracks, cards with different patterns) based on the descriptions provided in the Wright et al. (2006a) book because they have been designed specifically for Maths Recovery and were not commercially available.

In addition to the teaching materials, token economy systems and a variety of reinforcing items and/or activities were used for each child. For example, a child would be working on numeracy tasks for 10 minutes and during this time the therapist would reinforce appropriate working with placing tokens on his token board. When all the tokens had been acquired he could choose from a range of preferred activities, which included crafts (e.g., painting, collage, making play dough, etc), and favourite toys/games (e.g., Lego™ bricks, water or sand play, playing in the soft play area, computer games).

Measures

Two main outcome measures were used in the present study.

1. The Test of Early Mathematics Ability 3rd edition (TEMA-3, Ginsburg & Baroody, 2003), is an individually administered standardized test, designed to measure mathematical ability in children aged between 3 years 0 months and 8 years 11 months. The test includes both formal and informal tasks, such as verbal counting, counting items, reading and writing numbers, saying the number that comes after a given number, and story problems involving additions/subtractions. TEMA-3 yields a raw score representing the number of items the child answered correctly. The standard score of the test is called the Math Ability Score and is age referenced with a mean of 100 (SD = 15). A Math Ability Score between 90 and 110 is described as “average” for a typically developing child. The test also yields an Age Equivalent Score, or “mathematical age”. For example, a mathematical age of 60 months indicates that the child performs at the level of a typical 5-year old. The TEMA-3 has two parallel forms. Form A was used with all participants three times: before intervention, at the

end of the intervention period, and at follow up five months after post-testing. The test – retest reliability of Form A is .82 (Ginsburg & Baroody, 2003).

2. The Early Numeracy Curriculum-Based Measurement (EN - CBM, Clarke & Shinn, 2002; Clarke, Baker, Smolkowski, & Chard, 2008) consists of four subtests, which are timed and last for one minute each:

- Oral Counting (OC): the student counts from one up to as high as he can go in one minute.
- Number Identification (NI): numerals are presented in random order and the student identifies them.
- Quantity Discrimination (QD): the student needs to identify the larger number from a set of two.
- Missing Number (MN): the student is required to identify a missing number from a sequence of three consecutive numbers.

We made an adaptation to the format of NI, QD, and MN. Typically, the student is given a page containing boxes with all test items. To avoid the possibility of confusing the students if too many items were presented simultaneously, every testing item was printed on a card and was presented to the student separately. This had the added benefit of the numbers being of a larger font size. We administered the EN-CMB test twice, before the beginning and at the end of the intervention.

Initial assessment probes. After pre-testing for all children with the standardized assessments was complete, some more detailed testing on the Maths Recovery skills was necessary to help determine which skills each child needed to be taught. With intervention involving typically developing children, an initial assessment interview is conducted.

Because the level of language used in the interview can be confusing for children with autism (e.g., asking the child to describe the method he used to solve a task), we substituted it with probes corresponding to the individual numeracy skills, using simpler, more succinct instructions. A teacher who knew the child well decided at which developmental Maths Recovery stage the child would be tested (emergent, perceptual, etc). A therapist was given a list of the instructions for all the skills in that stage. For each skill two probes were conducted. If the child answered both correctly, it was assumed that he already had the particular skill. If he responded incorrectly for both probes, the skill would have to be taught. In the case of giving one correct and one incorrect response, two more probes were conducted for the same skill. If any further mistakes were made, the skill would be considered as not known to the child. Some of the children were tested on more than one stage. During pre-test trials the child was not given any prompts or corrective feedback. However, to maintain interest in the task, established reinforcers (e.g., praise, tickles, or short breaks with a favourite toy) were delivered intermittently between trials.

The assessment probes were intended only as a placement test within the Maths Recovery program and were not used to assess outcome.

Procedure

Overview of teaching procedure. Teaching based on the Maths Recovery teaching manual took place daily for approximately 20 weeks. Numeracy targets were incorporated into the child's individualized curriculum, and teaching took place in short sessions throughout the school day. On average, each student received 50-55 minutes of one-to-one Maths Recovery teaching per week. The therapists who normally worked with the child carried out sessions. Typically, the child was working on four numeracy tasks from different key topics at any one point in time.

The main teaching method employed was Discrete-Trial Teaching (DTT). Using a one-to-one therapist-child ratio, teaching began with the therapist presenting a cue or instruction to the child, if necessary prompting a response and finally rewarding correct responding by providing, for example, praise, the chance to play with a favourite toy, or a token which could later be exchanged for preferred activities. This single cycle of the behaviourally-based instruction routine (i.e., antecedent – behaviour - consequence), is known as a discrete trial. An example of how DTT was used to teach number identification is as follows: Three number cards were placed on the table in front of the child. Training trials for each receptive label were initiated by the teacher saying "Touch (number)". A correct response was defined as the child giving any selection response (e.g., touching, pointing to, or picking up number card) within 3 seconds of the start of the trial. All unprompted correct responses were reinforced immediately. An incorrect response was defined as the child touching an incorrect number card, doing nothing, touching more than one card, or taking more than 3 seconds to touch the correct number card. If the child was incorrect, no reinforcer was delivered and the trial was repeated. This time a prompt would be used, such as the therapist pointing to the correct number card, positioning the cards in a way that the correct number card was closer to the child, or physically guiding the child to point to the correct number. Prompted responses were immediately reinforced with praise. After the child was successful in solving the task when prompted, the therapist would begin to gradually remove help (prompt-fading), either by delaying the prompt or by reducing the level of prompting over consecutive trials until the child provided an independent answer.

Data on each current target was in most cases only recorded once in every teaching session. The therapist would present the task at the beginning of the session without any prompts and record whether the answer was correct or incorrect. The mastery criterion for each skill was three consecutive correct answers across three sessions; a three-day "retention" period during which the skill was not taught followed. If the child was still able to correctly solve the task after the retention period the skill was considered mastered. In some cases, when a child found a task too difficult, trial-by-trial data were collected at the ABA consultant's (CG) recommendation to help keep track of the precise nature of the learning problem.

Children with autism often do not automatically generalize skills learned at the table to different teachers, different teaching materials, or different instructions (Ghezzi & Bishop, 2008). Subsequently, we systematically planned for generalization of number skills using DTT at the table by incorporating a generalization step into every task. For example, if the child was able to count six counters when sitting at the table, in the generalization step he would be asked to count six different items (e.g. 6 cars), at a different location (e.g. the play area), by a different person (e.g. a therapist who did not normally work with him). The skill was only considered truly mastered when he was able to complete this step without prompts.

Another teaching method employed was frequency building. Thus, as some new number skills were learnt, time criteria were gradually introduced so that the children had to answer not only consistently and accurately but also quickly (i.e., fluently, see Binder, 1996). For example, for the task of expressively identifying numbers, the therapist rotated through a set of number cards 1 to 10 in random order for 1 minute (all required responses had been taught previously during DTT). The number of correct responses expected in one minute (i.e., "the aim") was based on the number that a typically developing child of similar age could achieve. Each child continued frequency building until they met this aim.

Staff Training - Fidelity of implementation

Prior to the beginning of intervention, we conducted two 2-hour training sessions on Maths Recovery with the therapists from the ABA unit who would be conducting the teaching. During this training, the Maths Recovery manual was described completely, including suggested teaching strategies, directions for data collection, and a list of teaching materials that would be needed to deliver the program. After this initial training, ongoing supervision of staff was provided by the second and third author during regular overlap sessions. During these sessions, therapists were provided with direct feedback regarding their teaching skills and further advice was given when necessary. This level of training helped to ensure that the therapists used a consistent approach in their teaching of numeracy skills and that they had similar expectations as to how each child should respond. In addition, as part of the regular policy in the ABA unit, fortnightly team meetings were conducted to discuss individual children's progress. Any issues around Maths Recovery targets were discussed alongside the other areas of each child's program.

To assess treatment fidelity, observations of approximately 5% of teaching sessions were conducted. Each observation lasted between 3 and 10 minutes and scores on two domains, treatment fidelity, and data collection fidelity, were recorded. For a treatment fidelity observation, an observer scored the therapist's performance on a checklist of questions regarding the organisation of the session, delivery of instructions, reinforcement delivery, error correction, and evidence of the child learning during the session. According to these data, treatment fidelity was on average 87%. For observations on data collection fidelity, an observer scored whether the child responded correctly to the tasks given to him and after the end of the session compared these recordings with the data the therapist had recorded. Data collection fidelity (i.e., observer agreement with the therapist on recorded data) was on average 93%.

Results

Pre- and post-intervention and follow-up scores for each child on the TEMA-3 are presented in Table 4.2. All six children made gains on this test by the end of the Maths Recovery intervention. The mean Math Ability standard score increased from 66.83 to 78.83 at post-test. Five of the six boys made an improvement of at least eight standard points. One child (Elias) gained 24 points and reached an age–appropriate level of skill reflected in a standard score of 100. Age Equivalent scores indicate that prior to intervention, all children but one (Malcolm) had a math age around three years. After the intervention, they had all made an improvement ranging between 9 and 15 months. Mean Age Equivalent Scores improved from 41 months at pre-test to 54.50 months at post-test.

A follow–up test was conducted approximately five months after the end of the intervention had ceased. With one child, Malcolm, there was a delay of about five additional months before the follow–up test due to scheduling difficulties. During the period between the end of intervention and the follow–up test, Elias, Aaron, Liam, and Stuart continued attending the ABA unit and they received numeracy instruction based on Maths Recovery but with less intense supervision. Mike and Malcolm had moved to different schools and their numeracy teaching was based on different curriculum. At the follow–up test, Stuart had gained another year of math age and eight points on his Math Ability score, Elias and Liam remained at about the same level, and Aaron and Mike showed a decrease in their scores. Malcolm kept the gains he had made but, despite showing a slight increase in his raw score and math age, had a decrease on the Maths Ability score because the rate of improvement was small compared to the time between the post and follow–up test.

Table 4.3 shows the results of the Early Numeracy Curriculum – Based Measurement (EN - CBM). Two of the four subtests comprising the EN - CBM subtests were accessed by

Table 4.2

TEMA-3 test results pre-, post- Maths Recovery intervention, and follow-up

Child	Raw Score			Math Ability Score			Age Equivalent (in months)		
	Pre-test	Post-test	Follow up	Pre-test	Post-test	Follow up	Pre-test	Post-test	Follow-up
Elias	1	14	18	76	100	99	<36	51	60
Aaron	0	14	8	63	80	65	<36	51	45
Liam	4	16	17	68	81	77	39	54	57
Stuart	1	10	20	60	68	76	<36	48	60
Mike	1	8	3	<55	56	<55	<36	45	36
Malcolm	25	41	43	79	88	79	63	78	81
Group Mean	5.33	17.17	18.17	66.83	78.83	75.17	41.00	54.50	56.50
SD	9.73	12.04	13.81	9.32	15.34	14.81	10.84	11.91	15.34

all participants: Oral Counting (OC) and Number Identification (NI). All the children improved on OC with mean group score per minute increasing from 9.33 at pre-test to 24.67 at post-test. Two children could not count at all at the beginning of the study, and at post-test the lowest score was 13 per minute. Improvement in NI was more modest (pre-test mean score 16 per minute, and post-test 27.50). This was an area where the children were relatively stronger at the beginning of the study. We also found during the intervention period that reading numerals was the key topic the children mastered most quickly. The fact that children with autism often possess strong visual skills may account for this. Two children, Elias and Stuart, were unable to recognize numerals prior to the program implementation. Both showed significant improvement at post–testing. Aaron and Liam had a small decrease in their NI performance after intervention, however, they still read about 20 numerals in one minute.

Malcolm was the only child who understood what he was expected to do with the Quantity Discrimination (QD = the child has to choose the larger number between two) and Missing Number (MN = the child says the number that is missing from a sequence of three) subtests. His pre-test scores were 10 per minute (QD) and 8 per minute (MN); at post-test he scored 15 (QD) and 9 (MN). The remainder of the children were not able to access these tests at pre-testing and this difficulty persisted at post-testing. There was one exception to this, Liam, who at post-testing scored 11 per minute on the MN task.

During the course of the study, Malcolm was working on Perceptual stage content and the rest of the children on the Emergent stage. By the end of the intervention period Elias, Stuart, Mike, and Liam had mastered all the targets of the “Numerals 1 to 10” key topic, but were still working on the other areas of the Emergent stage. Therefore, none of the children gained “arithmetic stages” as conceptualized in Maths Recovery during the intervention period.

Table 4.3

EN - CBM test results pre- and post- Maths Recovery intervention

Child	Oral Counting (OC)		Number Identification (NI)	
	Pre-test	Post-test	Pre-test	Post-test
Elias	0	20	0	35
Aaron	7	20	25	19
Liam	11	19	21	20
Stuart	10	17	1	16
Mike	0	13	15	17
Malcolm	28	59	34	58
Mean	9.33	24.67	16	27.50
SD	10.30	17.02	13.50	16.47

Note: All values represent number per minute

Discussion

In the present study, numeracy teaching based on the adapted Maths Recovery program was successfully incorporated within the individualized teaching programs of six children with autism receiving their education in an ABA setting. After receiving systematic teaching for a period of 20 weeks, all of the children had made gains. Data were also encouraging in relation to the maintenance of these gains at follow-up. Despite the limitations of the very small number of participants and the simple pre-test post-test design, we believe this is the first study to have evaluated a comprehensive numeracy curriculum (i.e., as opposed to intervention focusing on a specific mathematical skill) with elementary school students with autism. Our findings therefore have important applied implications.

Probably the most important implication for professionals working with children with autism is that the Maths Recovery teaching manual was shown to be a tool that can be used to teach early numeracy to children with different levels of ability. Some of our children had very little spoken language, or non-existent numeracy skills. However, all of the children were able to access the curriculum. Another positive aspect was that the structured layout of the manual (e.g., complex skills being broken into smaller steps, prompting suggestions being included in every lesson) and the systematic data collection, made it possible for the teaching staff both to identify a child's difficulty with a specific skill and to accommodate for it by adjusting the teaching procedure. For example, when 12 counters were placed on the table and Aaron was asked "how many counters?" he would count them by ones (1,2,...12) but was unable to reply to the next question "good, how many altogether?" A partial phonemic prompt (e.g., the therapist saying "tw...." immediately after asking the question) was introduced; then over the next trials the task was presented the therapist would aim for an independent answer. In another program when the child and the teacher take turns saying one number each (e.g., teacher: "1", child: "2", teacher: "3"), the visual prompt of a ball being passed back and forth between the two was used to help Aaron know whose turn it was to say the next number. For Liam, who would often make errors when sequencing number cards, initially the therapist would place the first number card (e.g., 1 for numbers 1-5) and Liam would continue with the rest of the cards. After he was successful with the task with this prompt, the therapist would start withholding this help so he could solve the task independently. With another child who found this task (sequencing number cards) more challenging a backward chaining procedure could have been used instead. The initial step would involve the therapist ordering the first 3 number cards (1-3) and then the child completing the sequence with numbers 4 and 5; as a next step two number cards would be ordered by the therapist and the last three by the child, and so on, until the child was able to sequence all five number cards by himself.

Regarding the children's numeracy progress following the intervention, the results suggest that effects were positive. Improvements on the TEMA-3, which assesses a variety of skills, give a more general picture of a child's numeracy level, as indicated by the Maths Ability and Age Equivalent (mathematical age) scores. At the beginning of the study, five of the six children demonstrated very low numeracy skills, and four of them performed below the level of a 3-year old child. They were, for example, unable to complete simple tasks such as counting 3 cats in a picture or 5 digits on one hand. Following intervention, all of the children except Mike had a mathematical age of more than four years and were able, amongst other skills, to count about 20 items one-by-one, recognize patterns such as four dots in a dice configuration without counting, and show the required number of digits.

The EN-CBM subtests offer a glimpse into the children's performance on a few specific skills. All six children showed improvements in their counting skills (OC, minimum score 13) and were able to recognize written numbers (NI, lowest score 16 numbers per minute) after being taught with Maths Recovery. There were almost no changes on their ability to identify the larger of two numbers (QD) and the missing number from a sequence of three consecutive numbers (MN). According to Clarke et al. (2008) these two subtests (QD and MN) require more complex strategies than OC and NI. It is possible that, in spite of their progress, the children did not reach the arithmetic level required for these tasks, a hypothesis that is supported by the math age scores on the TEMA-3. At the end of intervention the mathematical age of the five children who did not access the QD and MN subtests was between 3 years 9 months and 4 years 6 months. The EN-CBM tasks are intended for kindergarten age children (ages 5 to 6 years). Malcolm, the only child who could access both QD and MN, had a higher mathematical age of 5 years 3 months (pre-test) and 6 years 6 months (post-test). Another consideration with QD and MN is that these skills had not been specifically targeted during intervention. Although the children had worked on similar skills, for example, putting number cards in order, this knowledge was not generalized to the new tasks (e.g., missing number) with the exception of Liam.

Individual gains on outcome measures showed variability (e.g., Math Ability gains range between 1 and 24 points), suggesting a different pace of learning among participants.

The youngest of the children (Elias, 4 years old) made the greatest improvement: his Math Ability score increased by 24 points, and he reached age appropriate levels as indicated by both the Math Ability (100) and the Age Equivalent (chronological age = 4 years, 7 months, maths age = 4 years, 3 months) scores at post-testing. Improvements of the other five children were considerable although less dramatic. Even when the gains were small, however, it is encouraging that the child made some progress in an academic area which many typically developing children find difficult. Mike, one of the older children in the group (6 years, 9 months) increased his Math Ability score by just one point. However, as indicated by his Age Equivalent scores, prior to intervention his numeracy skills were lower than those of a 3-year-old child, so it is noteworthy that six months of teaching using this approach helped him gain at least 9 months in mathematical age—an improvement that would be considered positive for a child without learning difficulties. Additionally, according to anecdotal reports from his mother, Mike was generalizing his newly acquired numeracy skills and using them at home by singing counting songs, counting pictures of items, and recognising numbers in books; these were things he had not been doing prior to the study.

In contrast with findings from previous research conducted with typically developing children (Bobis et al., 2005; Willey et al., 2007) our participants did not gain any Maths Recovery arithmetic stages. Although the very small number of participants makes it difficult to draw any solid conclusions on why this maybe the case, the fact that children with autism often have additional learning difficulties might account for a slower pace of learning compared to typically developing children. There was also an important difference between our study and the other projects evaluating Maths Recovery. We used the program as the sole numeracy curriculum for the six children, some of whom had never before been exposed to any mathematics teaching. In the projects with typically developing children, the intervention is being offered to children who have already have had some group teaching in the mainstream classroom. Consequently, previously acquired numeracy knowledge levels differed between our children and the participants in other Maths Recovery evaluation studies.

The final aim of the project was to assess whether the children would maintain the post-intervention gains after the end of the project. The follow-up test, conducted 5 months after the end of the study (10 months later for Malcolm) showed that three out of the four children who continued to be taught with Maths Recovery but under less strict supervision, continued to make gains and their Maths Ability standard scores were stable (Elias and Liam) or had increased (Stuart). The fourth child (Aaron) had a decline in his skills and was often non-responsive during the follow-up test. Of the two children who moved to a different school environment after the end of the Maths Recovery project, and were therefore being taught with different mathematics curricula, Malcolm had kept all the gains he had made at post-testing and had made some further progress. For example, he was able to solve addition (6+3, 4+4) and subtraction (2-1, 8-4) tasks by counting-on and counting-back, which he had not been able to complete at post-testing. Mike, on the other hand, had lost many of his acquired skills and his score decreased to nearly as low as his pre-intervention level. It is possible that these numeracy skills had not continued to be targeted in the new school environment and, as a result, had not been maintained. This finding supports a practice implication that educators working with children with autism revisit mastered targets from time to time and ensure their maintenance.

Further research is needed to extend our pilot findings by examining the effectiveness of the program over a longer period of time, with larger samples of participants, and including a control group in the study design. Another consideration would be to explore the use of the curriculum with different populations (e.g., children with intellectual disabilities). Finally, it would be interesting to assess whether the curriculum could be used in standard special educational settings that are not ABA-specific and may not have the kind of staff student ratios or the expertise in behavioural methodologies (e.g., prompting and prompt-fading) common in these settings.

Chapter 5. An Individualized Numeracy Curriculum for Children with Intellectual Disabilities: A single blind pilot randomized controlled trial[3]

[3] The following persons contributed to the empirical study presented in this chapter and will referred to as co-authors: Richard Hastings, Corinna Grindle, Carl Hughes and Zoë Hoare

Abstract

Research investigating structured, comprehensive numeracy curricula that can be used with children with Intellectual Disabilities (ID) is limited. We evaluated an adaptation of the Maths Recovery program. Twenty four elementary school children with severe ID or autism were randomly allocated into the intervention and control groups with twelve children in each group. For 12 weeks, children in the intervention group received individualized numeracy teaching based on the adapted Maths Recovery curriculum, whereas children in the control group received "mathematics as usual" teaching. Pre- and post- intervention tests on standardized numeracy measures were conducted. Results indicated that the Maths Recovery group made significant improvements at post-intervention in comparison to the control group. A follow-up test showed that gains were maintained seven months after the end of the intervention. Implications for practice are discussed.

One of the main mathematical domains defined by the US National Council of Teachers of Mathematics (NCTM, 2000) is numeracy (or numbers and operations). Numeracy involves being able to understand and represent numbers, relationships among numbers (e.g., place value), and number operations (addition, subtraction, multiplication, & division). Mathematics is a curriculum area that many students with intellectual disabilities (ID) find difficult, and they often do not acquire even the basic numeracy skills during their school years (Buttler et al., 2001). These deficits impact vital areas of everyday life such as being able to use money or understand quantities. Therefore, limitations in numeracy may affect a person's quality of life into adulthood (Ayres, Lowrey, Douglas, & Sievers, 2011; Patton et al., 1997; Rivera, 1997).

Although attention given to numeracy instruction within the field of educational research for students with special educational needs has been increasing in recent years (Gersten et al., 2009), most of the published studies have focused on children who have mild disabilities or are "at risk" of later disabilities (Gersten et al., 2009; Kroesbergen & Van Luit, 2003; Miller, Buttler, & Lee, 1998). In a systematic review, Buttler, Miller, Lee, and Pierce (2001) located 16 studies on mathematics interventions for students with mild to moderate ID spanning a 10-year period (1989-1998). Buttler et al. concluded that explicit instruction, frequent feedback and repeated opportunities for practice were successful methodologies with this group of children. Another finding of the review was that the majority of studies targeted the relatively more advanced mathematical skills of computation (number operations) and problem-solving, thus moving on from the tradition of teaching mostly basic skills (e.g., number recognition, counting) to this population.

Focusing on mathematical interventions for students with significant cognitive disabilities, Browder et al. (2008) reviewed 68 studies published between 1975 and 2005. Participants had diagnoses of moderate/profound/severe ID or autism. Of these, 54 involved single subject designs and 14 used a group design. Just over a half (54%) of the included studies targeted numeracy skills (e.g., counting, matching numbers, calculations). Browder et al. (2008) found only 17 studies that focused exclusively on participants with severe or profound ID; 6 of these focused on teaching numeracy skills: counting (2 studies), matching numbers (2 studies), and number operations (2 studies). The overall conclusion of Browder et al.'s review was that systematic instruction, including clearly defined teaching goals, prompting and prompt-fading strategies, was the general procedure associated with the best outcomes.

Despite a body of literature and helpful reviews, the information presently available to practitioners working with students with ID is limited in a number of areas. For example, most studies have focused on teaching a specific skill such as counting items or matching numerals. Information is scarce in terms of structured and comprehensive curricula appropriate for this population that would help practitioners teach all numeracy domains. There is some research on the use of the TOUCHMATH program (Bullock & Walentas, 1989), a commercially available program that employs numerals with the equivalent number of dots on each numeral (i.e., one dot on 1, two dots on 2 etc.) to teach number operations (addition, subtraction, multiplication, and division). Using this program, students touch each dot as they count forwards or backwards. The existing evaluation studies on TOUCHMATH for children with ID have focused on teaching addition and subtraction skills to students with mild or moderate ID. Scott (1993) used the program to teach addition and subtraction to two elementary-aged children with mild ID. More recently, the program was used to help three high school students with mild ID learn to solve 3-digit subtraction problems involving money (Waters & Boon, 2011). In another project, Fletcher, Boon, and Cihak (2010) used TOUCHMATH to successfully teach addition to three middle school students with moderate ID. Fletcher et al. demonstrated that the TOUCHMATH program was more effective than an alternative strategy, that of using a number line. We could find no existing research on the effectiveness of the program across a wider range of numeracy skills.

In the research literature on teaching mathematics skills to children with ID, there are few high quality group design studies (i.e., randomized experimental designs including a comparison or control group). Another methodological weakness is the limited use of standardized measures - most researchers have used measures corresponding to the specific skill targeted in the intervention. For example, only two of the 14 group studies included in the Browder et al. (2008) systematic review used standardized measures.

In our previous research on numeracy interventions with children with autism, we found a similar shortage of structured, comprehensive curriculum guides that can be used by practitioners to systematically and effectively teach these children. We adapted an existing numeracy curriculum, the Maths Recovery program (see Chapter 3 of the present thesis). Maths Recovery is a curriculum that has been originally designed for typically developing children who were performing poorly in mathematics (Wright et al., 2006b) and has been successfully implemented in several countries (Smith et al., 2010; Willey et al., 2007; Wright, 2003). The program covers numeracy skills ranging from very early (e.g., counting 1-20, recognizing numerals 1-10, being able to count up to 20 items, counting using fingers) to advanced (e.g., counting by 10s and 100s to 1000, addition/subtraction of two-digit numbers, word problems involving multiplication/division). We used Maths Recovery to conduct a preliminary evaluation study with six children with autism who were enrolled in an Applied Behaviour Analysis (ABA) autism setting. Comparisons of pre- and post-intervention scores using standardized numeracy measures showed that, after 20 weeks of intensive one-to-one instruction, all six children had improved their numeracy skills and had made gains of between 9 and 15 months of mathematical age.

The purpose of the present study was to extend our previous research by using Maths Recovery with children with severe ID who do not have autism. We also adopted a strong experimental design and a larger number of participants than our initial autism research. We employed a waiting list control group design and compared the progress of a group of children who were taught individually with Maths Recovery to that of a similar group of children who received “mathematics as usual” teaching within the school setting. We conducted the present study in a special needs school, where the ratio of staff to children was much lower than the one-to-one typical for ABA settings and where there was limited awareness of ABA teaching methodologies. Our aims for this study were, therefore: (1) To determine whether children with severe ID who were taught individually with the Maths Recovery program, would make better numeracy progress than a similar group of children who received instruction with the mathematics curriculum used by the school, and (2) To explore whether any numeracy improvements for the intervention group would be maintained over time.

Method

Participants and setting

Twenty four elementary school children participated in the study. Twelve received one-to-one numeracy teaching with the Maths Recovery model and 12 continued with “mathematics as usual” instruction within their classrooms. All were attending a special needs school in North Wales which serves students with severe intellectual disabilities. The children had been identified by their class teachers as requiring support with mathematics. Nineteen had a diagnosis of severe ID and five were diagnosed with an Autism Spectrum Disorder (ASD). Eleven of the twenty four children had an additional medical condition. All had some verbal capabilities ranging from using single words to being able to talk in full sentences. Descriptive information about the two groups of children is provided in Table 5.1.

Table 5.1

Participant Characteristics

Variable	MR group (n=12)	Control group (n=12)
Gender		
Male	7	9
Female	5	3
Age in months		
Range	75-132	69-134
Mean	100.25	100.00
SD	18.93	20.42
Main Diagnosis		
Severe ID	9	10
Autism	3	2
Additional Diagnoses/ Medical conditions		
ADHD	1	-
Epilepsy	-	1
ADHD & Epilepsy	-	1
Microcephaly	1	-
Fragile X syndrome	-	1
Down syndrome	-	1
Rubinstein-Taybi syndrome	1	-
Chromosome 6 deletion	-	1
Spina Bifida & Hydrocephalus	1	-
Cerebral Palsy	1	1

Interventions

The Maths Recovery Model

The Maths Recovery early numeracy curriculum is based on an instructional framework (Wright et al., 2006a; 2006b) consisting of five progressive stages of sophistication:

1. Emergent Stage: the child has few counting skills. Instructional targets include facility with number word sequences up to 20, numerals 1 to 10, counting collections of visible items, spatial patterns up to 6 (e.g., recognizing dice-like configurations without counting the dots one-by-one) and finger patterns (counting using one's fingers).

2. Perceptual Stage: the child can count and solve some additive tasks when items are visible. Targets for this stage include number word sequences to 30, numerals up to 20, doing additive tasks involving screened collections of items, more advanced spatial and finger pattern activities and some basic multiplication and division tasks using items.

3. Figurative Stage: when solving additive tasks the child counts from one. Target skills include word sequences and numerals to 100, counting-on and counting-back to solve additive and subtractive tasks and facility with partitions of 5 and 10.

4. Counting-on and Counting-back Stage: the child can solve additive task by counting-on and subtractive tasks by counting-back. Target skills to further his numeracy abilities include number word sequences by 2s, 3s, 4s, 5s and10s in the range 1-100, numerals up to 1000, incrementing and decrementing by 10s and 1s, adding to and subtracting from decade numbers, multiplication and division tasks.

5. Facile Stage: the child can count by 2s, 3s, 5s and 10s. Skills targeted include number word sequences by 10s and 100s off the decade, two-digit additions and subtractions and advanced multiplication and division tasks.

Activities within each stage are grouped into Key Topics (numeracy areas). For example, the Emergent stage includes the following Key topics: (a) Number word sequences 1-20, (b) Numerals 1-10, (c) Counting up to 20 visible items, (d) Spatial patterns (recognising patterns on cards without counting), (e) Finger patterns (different ways of counting using one's own fingers), and (f) Temporal patterns and temporal sequences (copying and counting patterns of sounds and movements).

To make the Maths Recovery curriculum more easily accessible by children with developmental disabilities we developed a teaching manual (described in more detail in Chapter 3 of the present thesis; see also Appendix 6) containing all the activities described in the Wright et al. "*Teaching Number*" (2006a) book. The following modifications were made to each target skill:

- The learning goal was clearly specified. To help practitioners determine when this goal was achieved, a mastery criterion was also described.
- An additional generalization step was added to every task to ensure the child could be successful with the task with a variety of materials, in multiple environments and with a different teacher. This addition was especially important for children with autism who often need help with generalizing acquired skills.
- Some complex skills were broken into smaller steps to facilitate teaching and learning.

- We developed a more systematic approach to instruction by: (a) shortening verbal instructions and specifying phrases for teachers to use, and (b) including prompting and prompt-fading instructions for each step of the target skill.

A further modification to the procedure followed by Wright et al. (2006a; 2006b) involved the assessment of the child's level of numeracy skills prior to the intervention. With typically developing children, an assessment interview would normally be conducted during which the teacher would often ask the child to describe his strategies for solving a task. We conducted a probing session instead, presenting instructions to the children in a simpler and more succinct language. The child was asked 2-3 questions corresponding to each skill listed in the manual. If he/she answered correctly the skill was considered known to the child, otherwise it had to be taught. The purpose of this probing session was to help us determine which Maths Recovery skills we would teach each child and this procedure was not part of the study outcome measurement. All probing sessions with the children in the intervention group were conducted by the first author. No feedback was given to the child during these sessions (i.e., regarding correct or incorrect responding); we did however reinforce him/her for attending and working nicely with praise and short breaks with a favourite activity.

Based on each child's performance on the Maths Recovery probes, numeracy lessons from different areas of the Maths Recovery manual were chosen. For example, a child's targets could include: (a) Counting from 1 to 10, (b) Reading a number-line 1 to 5 forwards and backwards, (c) Count 3 to 5 fingers sequentially without looking at his fingers, and (d) Counting collections consisting of 6 to 8 items. For most of the children, targets from the Emergent stage similar to the ones just mentioned were chosen. A small number of children who had more advanced numeracy skills were able to access the Perceptual or the Figurative stage and were working on tasks such as counting forwards up to 100, counting backwards 30 to 1, adding the items of two collections when one collection was screened, or ordering number cards in the range 30 to 100.

For the 12 weeks of intervention, the children in the Maths Recovery group received one-to-one numeracy teaching following the manual. The intervention was delivered either by a teaching assistant who worked in the child's classroom or by the first author who is a qualified teacher and offered to undertake some of the teaching in classes that had many children participating in the study. Teaching took place in different quiet areas within the school. In most cases, a small room off the main classroom was used. For a few children, a quiet area within the classroom was used instead.

We used a Discrete-Trial Teaching (DTT) procedure. Each discrete trial comprised three components: the teacher's instruction to the child, the child's response (which could be prompted by the teacher if necessary), and finally the teacher rewarded correct responding by providing a high five, praise, a short interval of playing with a toy, or a token which could later be exchanged for a favourite activity. When the child was unable to complete the task, the instructor would present the same task in the next trial with a prompt, thus partially helping the child to respond. Once the child was able to respond correctly when the prompt was provided, the instructor would attempt the removal of the prompt (prompt-fading) during following presentations. Prompting and prompt-fading directions for each skill were included in the manual (Appendix 6). In some cases, when a child had persisting difficulties with a task additional prompting suggestions were discussed by the intervention team. As DTT allows for a fast pace of teaching, the child had many opportunities to work on each of their four numeracy targets throughout the session. The instructors varied the order in which the tasks were presented. In addition, as the children progressed in their learning targets, questions on previously mastered skills were intermittently asked to ensure retention of those skills and to vary the level of difficulty of the tasks within the session.

Data on each of the child's targets were recorded once in every session. The instructor presented the task to the child without prompting and a correct or incorrect response was recorded on the data sheet for the skill. The mastery criterion for each skill (or sub-step of a skill) was three correct answers across three consecutive sessions.

Table 5.2

Number of session and total instructional time for children of the intervention group

Cases	Sessions	Total duration (min)
Child 1	13	210
Child 2	13	265
Child 3	14	225
Child 4	15	305
Child 5	19	350
Child 6	21	255
Child 7	22	420
Child 8	22	425
Child 9	24	390
Child 10	31	590
Child 11	33	620

Our initial intent was for every child to have 4-5 intervention sessions per week. However, this did not prove to be possible in practice. Intensity of intervention was, therefore, variable. Some of the children had as few as 13 individualized sessions in total whereas others had over 30 teaching sessions during the course of the study. Sessions typically lasted between 15 and 20 minutes. Thus, total instructional time for the children in the Maths Recovery group ranged from 3 hours 30 minutes to 10 hours 20 minutes. Detailed information on the number of sessions and total instructional time each child received is presented in Table 5.2.

Training the school staff to implement the Maths Recovery intervention involved a number of steps. Initially, two 2-hour training sessions on the program were conducted by the first author with the teaching assistants who would be delivering the intervention. The teaching manual, materials and teaching procedures were discussed during these initial sessions. As a second step, after pre-testing with the standardized measures and the Maths Recovery placement probing were complete, one or two teaching sessions were conducted with each of the intervention group children and the teaching assistant who would be working with the child. During these individualized training sessions, the first author modelled teaching each the child's targets and the teaching assistant had the opportunity to practice teaching and discuss any questions about the procedure. Once the teaching assistant felt confident about delivering the intervention, he/she took over the child's teaching. Throughout the course of the study, formal and informal meetings between the teaching assistants and the first author were conducted to discuss issues concerning individual children's progress.

Each teaching assistant worked with one or two children. For two of the classes, the first author taught some of the children. The same person throughout the study taught the same child.

Mathematics as usual teaching

Children in the control group had four to five 1-hour sessions of mathematics teaching per week as a part of the typical mathematics instruction in the school. At least two of these sessions covered numeracy targets. Typically, each session started with whole-class activities which included oral counting, identifying numerals, counting groups of items, or copying patterns of sounds. The children were then divided into small groups where they engaged in a variety of numeracy activities (e.g., sorting numerals, matching numerals to quantities). During the remaining weekly sessions, the children received instruction on other mathematical components such as measurement and geometry.

Materials

We used a range of teaching materials that correspond to the various Maths Recovery skills. For example, materials for teaching Key Topic 2 (numerals) included number cards for individual numbers, number lines (1-5, 1-10, 11 – 15, etc), numeral tracks (number lines with a small cover for each numeral), and the 100-square (a 10 x 10 square containing numbers 1 – 100). Collections of items such as counters and laminated pictures of items such as cars, dolls, and insects were used for the skills of Key Topic 3 (counting visible items). Domino cards with 1-6 dots and cards with 1-4 dots in irregular patterns were used with other resources for Key topic 4 (spatial patterns).

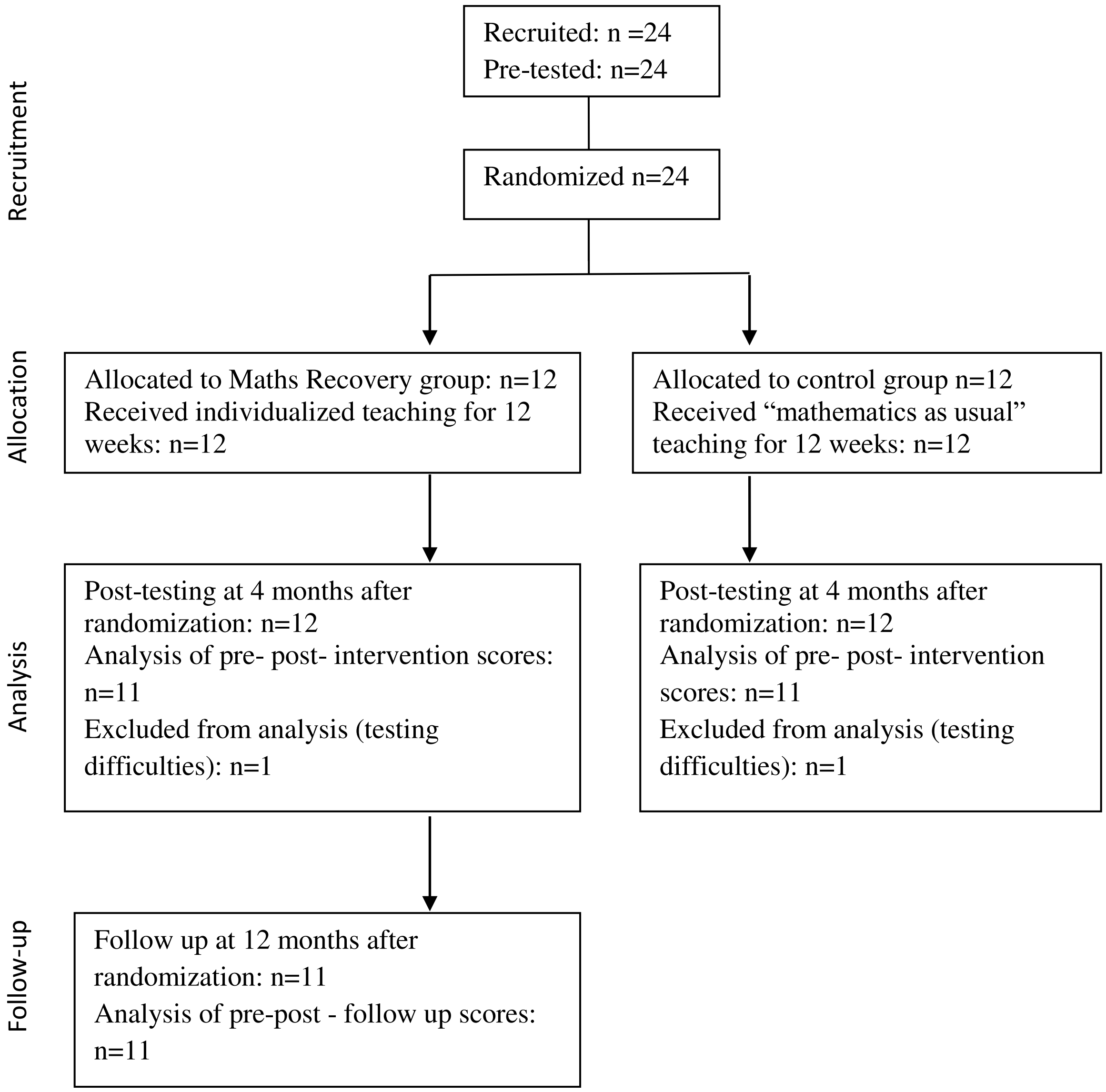
In keeping with ABA teaching methodology, a variety of items and activities were used as reinforcers for each child based on his/her preferences. Insert and jigsaw puzzles, story books, bubbles, small toy cars, animals, building blocks, colouring pencils and drawing books were some of the items that we used. With some of the children, a token board system was also utilized. Tokens were placed on the board contingent on appropriate working. When all the tokens had been acquired, the child could choose one of the reinforcement items/activities and engage with it for a few minutes. A 20-minute teaching session could include three 5-minute intervals of work on the child’s numeracy targets with two minutes of play at the end of each interval. A few of the older children who were able to work for longer periods would work for about 15 minutes and then have a 5-minute play activity at the end of the session.

Recruitment, Randomization and Blinding Procedure

Twenty four children enrolled in the elementary department of the school were identified by their class teacher as likely to benefit from an individualized numeracy intervention. Parents of the children were sent a letter informing them about the aims of the study and about our intention to randomly allocate children into the intervention and control groups. The study information sheet explained that children in the control group would also receive Maths Recovery intervention during the following school year from the teaching staff who would have been trained by the research team during the course of the current project. All parents consented to their child's participation in the study. A randomization protocol was created for the needs of the study by the collaborating clinical trials unit (Appendix 9). The children attended five different classes within the school, and it was important for practical reasons to have balanced numbers of students who received one-to-one instruction in each class. This was because the intervention would be delivered by the teaching assistants within each class, something that would affect the staff-to-children ratio within classes. Therefore two randomization criteria were used: the class the children were enrolled in, and their main diagnosis (severe ID or ASD).

Once parents' consent had been secured, the 24 children were pre-tested on the standardized measures described in the next section. Children's information was then entered into the randomization template and emailed to the trails unit. Using block randomization, the 24 children were allocated into the intervention and control groups with twelve in each group (ratio 1:1) and the results were emailed to us on the next working day. A consort style diagram summarizing the design is presented in Figure 5.1. After the end of the intervention period (4 months post-randomization), all 24 children were again tested on the same standardized measures. Persons who were not otherwise involved with the study

Figure 5.1: *Consort style diagram*



conducted all testing sessions, and so testers were blind as to which group the child belonged. For 23% of testing sessions, a second assessor scored the child's performance. Using the percentage agreement index method, inter-rater agreement on the child's scores was 99.7% (range 97-100%). Two participants with a diagnosis of autism, one from each group, were not cooperative during testing and we were unable to use their data. Therefore, results for 22 children, 11 in each group, were used in the final analysis.

To assess whether the post-intervention gains had been maintained a follow–up test on one of the standardized measures was conducted with the children in the Maths Recovery intervention group only approximately 12 months after randomization.

Measures

Two main outcome measures were used in the present study:

The Test of Early Mathematics Ability 3rd edition (TEMA-3, Ginsburg & Baroody, 2003), is a standardized test designed to measure mathematical ability in typically developing children aged between 3 years 0 months and 8 years 11 months, which can also be used with older children with mathematical learning difficulties. The test includes a variety of numeracy tasks, such as verbal counting, counting items, reading and writing numbers, saying the number that comes after a given number, and story problems involving additions/subtractions. The TEMA-3 has two parallel forms, A and B. Each of the 24 children was tested with the same Form (some with A and some with B) at two time points: before intervention, and at the end of the intervention period. For the children in the intervention group, an additional follow up test (using the same Form as in the previous two tests) was administered seven months after post-testing (12 months post-randomization). The test – retest reliability for Forms A and B are .82 and .93 respectively (Ginsburg & Baroody, 2003). TEMA-3 yields a raw score, a Math Ability score and an Age Equivalent (mathematical age) score. Because the test has been designed for typically developing children up to the age of 8 years 11 months, Math Ability standard scores cannot be calculated for older students. As the age range of our children was up to 11 years 2 months, we were able to use only the raw and age equivalent scores for this test.

The Early Numeracy Curriculum-Based Measurement (EN - CBM, Clarke & Shinn, 2002; Clarke et al., 2008) consists of four subtests, which are timed and last for one minute each:

1. Oral Counting (OC): the student counts from one up to as high as he can go.

2. Number Identification (NI): numerals are presented in random order and the student identifies them.

3. Quantity Discrimination (QD): the student needs to identify the larger number from a set of two.

4. Missing Number (MN): the student is required to identify a missing number from a sequence of three consecutive numbers.

As for our previous study with children with autism (described in Chapter 3), a small adaptation was made to the format of NI, QD, and MN. Instead of presenting the child with a page containing boxes with all test items, we printed each item on a card and presented one item at a time. This was done to help avoid the possibility of confusion if the students were presented with too many items at once. Participants of both groups were tested on the EN-CBM subtests twice, at the beginning, and at the end of the intervention period.

Results

Results for the TEMA-3 test and the Oral Counting (OC) and Number Identification (NI) subtests of the EN-CBM are summarized in Table 5.3. Because there were differences between the mean scores of the two groups at pre-intervention, we conducted ANCOVA analyses to evaluate the effects of the Maths Recovery intervention. We compared the post-intervention scores of the two groups while controlling for pre-intervention scores. The results indicated that the intervention group made significant gains on the TEMA-3 at post-test in comparison to the control group. On the EN-CBM test results there was a small difference in favour of the intervention group on the OC subtest and no statistically significant difference on the NI subtest. The OC results of one child in the Maths Recovery intervention group were not included in analysis. This child had scores of 10 at pre-testing and 65 at post-testing. However, as indicated by his TEMA-3 scores and his general performance during the intervention period, the low pre-intervention score was likely due to a lack of confidence rather than to his inability to count above 10. Therefore, this child's score was judged to be an outlying data point.

As for the remaining two subtests of the EN-CBM, Quantity Discrimination (QD) and Missing Number (MN), many of the 22 children were unable to access them either at pre- or at post-intervention. Five children in the intervention group and seven in the control group were able to complete QD, whereas MN was accessed by six children in the intervention and seven in the control group. The children in the Maths Recovery group who were able to score on the subtests showed improvement in scores at post-treatment time: QD pre-test Mean = 9.00 (SD = 8.48), post-test Mean = 9.80 (SD = 7.15), and MN pre-test Mean = 6.33 (SD = 6.25), post-test Mean = 11.17 (SD = 10.08). The control group had a small decrease in the two subtests: QD pre-test Mean = 11.14 (SD = 5.92), post-test Mean = 9.43 (SD = 3.95) and MN pre-test Mean = 4.57 (SD = 6.21), post-test Mean = 3.71 (SD = 2.28).

Effect sizes (Cohen's *d*) for the intervention effect were calculated using the method recommended by Morris (2008). The mean pre-post difference for the Maths Recovery intervention group minus the pre-post difference of the control group was divided by the pooled pre-test standard deviation. Effect sizes were moderate for the TEMA-3 scores and small for the OC subtest.

Table 5.3

Pre-, post intervention and follow-up scores for the intervention and control groups

	MR Intervention Group (n=11)			Control Group (n=11)				
	Pre-test	Post-test	Follow -up	Pre-test	Post-test	ANCOVA		Cohen's *d*
	M (SD)	M (SD)	M(SD)	M (SD)	M (SD)	F	p	
TEMA-3 raw	7.18	13.82	14.27	10.27	10.27	31.7	<.00	.67
score	(9.54)	(11.83)	(13.65)	(9.66)	(9.36)	4	1	
TEMA-3 math	43.36	51.55	52.64	48.27	48.55	17.9	<.00	.66
age[a]	(11.72)	(14.18)	(15.72)	(11.42)	(11.21)	3	1	
Oral	13.10	17.70	-	15.00	15.00	3.42	.081	.43
Counting	(11.21)	(11.71)		(9.33)	(11.29)			
Number	13.18	15.64	-	12.55	13.55	0.31	.583	.11
Identification	(12.25)	(12.15)		(12.72)	(14.62)			

Note. ANCOVA analyses and Cohen's *d* have been calculated for the pre- post- test data only.

[a]Maths age in months.

Because the number of children with an ASD diagnosis was not balanced across the two groups and ASD participants in the Maths Recovery group had high post-intervention scores, we run the analyses again excluding data of children with ASD across the two groups. We found that the pattern of results remained unchanged.

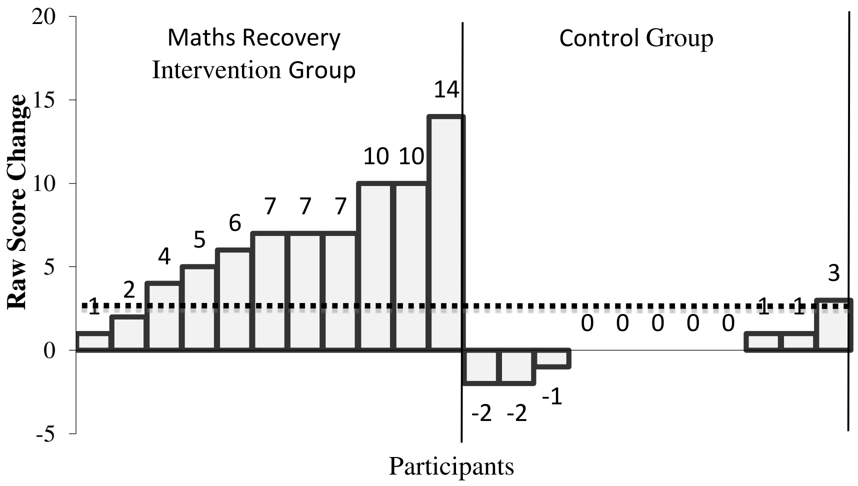
Additional analyses were conducted to assess whether post-test scores of the Maths Recovery intervention group were impacted by the person delivering the intervention. Results indicated there was no such impact.

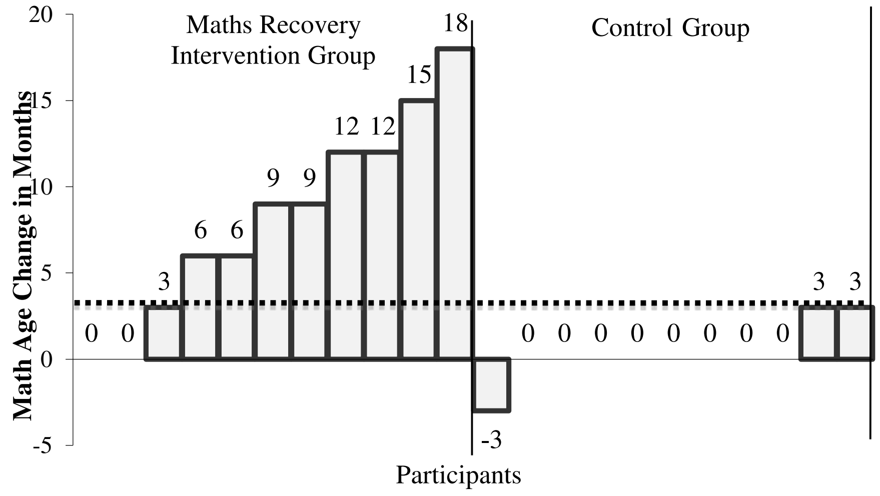
Children in the Maths Recovery intervention group had an additional follow-up test on the TEMA-3 approximately 7 months after the end of the intervention (12 months post-randomization). These follow-up mean scores showed a slight increase compared to post-intervention (see Table 5.3). Repeated measures t tests revealed that there were no statistically significant changes between post-testing and follow-up for Raw Scores ($t(10) = 0.63$, $p = .541$) or for Age Equivalent scores ($t(10) = 1.00$, $p = .341$) on the TEMA-3. Thus, there was evidence of maintenance of the intervention effects over time.

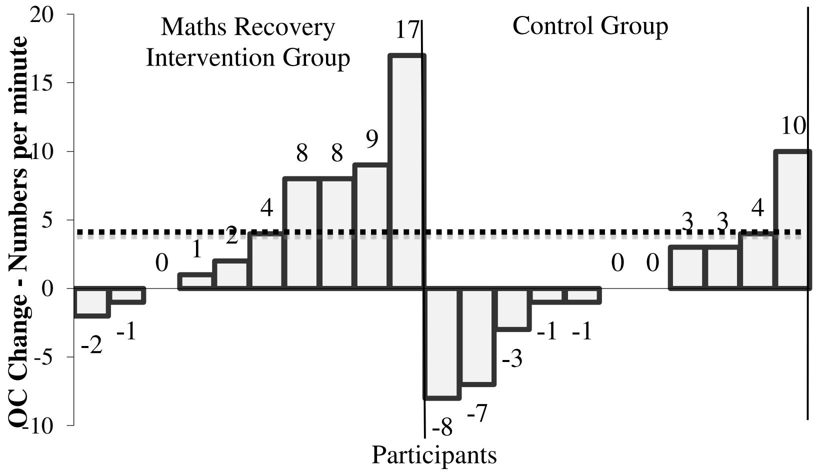
Analysis of change at the individual child level

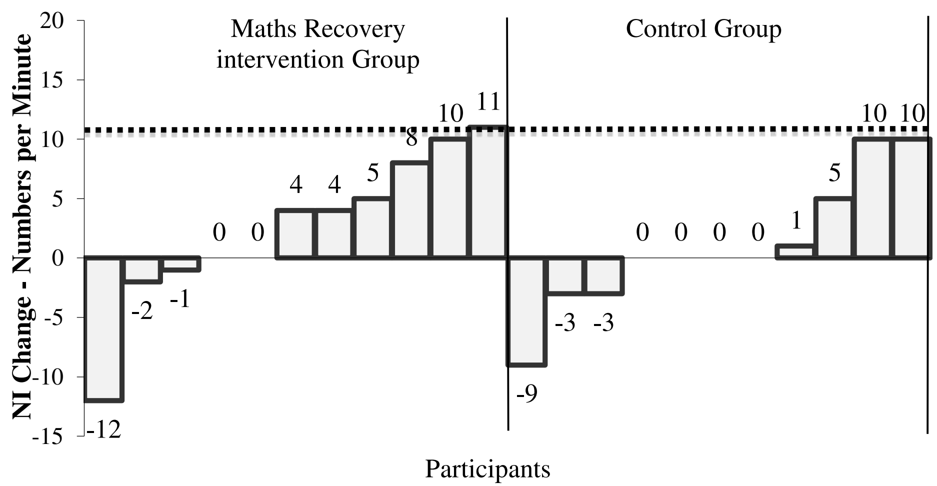
To evaluate change for individual children, we conducted an analysis of reliable change (Reliable Change Index - RCI, Jackobson & Truax, 1991). The RCI focuses on the amount of pre to post-intervention change necessary for the gains to be considered meaningful and unlikely to have occurred by chance. Figure 5.2 shows the results of the reliable change analysis on the TEMA-3 and the OC and NI EN-CBM subtests. Nine of the 11 children in the intervention group improved their mathematical age at post-test (range between 3 and 18 months) and eight of them achieved reliable change. Two of the control group children showed 3 months of mathematical age improvement and another child had a 3-month decrease. None of the children in the control group reached a reliable change level. On the OC test, children in the intervention group generally made larger gains than the control group children but only one child in each group achieved an increase above the reliable change level. Data from one of the intervention group children was excluded from this analysis because the score was an outlier. Finally, NI results show greater individual variability, and none of the children reached a reliable change level.

Figure 5.2: *RCI results*. Bars represent the change of individual children's scores between pre and post-intervention testing. The dotted lines indicate the change required to exceed the reliable change index criterion. Top row graphs show the TEMA-3 raw scores and math age scores. OC and NI scores of the EN-CBM test are shown in the bottom row graphs.


Raw Score Change
Maths Recovery Intervention Group
Control Group
Participants


Math Age Change in Months
Maths Recovery Intervention Group
Control Group
Participants


OC Change - Numbers per minute
Maths Recovery Intervention Group
Control Group
Participants


NI Change - Numbers per Minute
Maths Recovery intervention Group
Control Group
Participants

Discussion

The overall study outcomes were positive. The intervention group made a significant gain on the TEMA-3, which covers a wide range of numeracy skills across different levels of ability and therefore is the most comprehensive of the two tests we used. After 12 weeks of individualized teaching, the Maths Recovery group improved their mathematical age by an average of 8.18 months whereas the control group made an improvement of .27 months on average. Focusing on individual participants, eight children (73%) of the Maths Recovery group made a gain of at least 6 months of mathematical age, something that none of the control group children achieved. Scores of two children in the Maths Recovery group remained unchanged after the intervention. For the specific skills measured by the EN-CBM test, which is a fluency-based measure (number of correct answers per minute), although the intervention group made generally better progress than the control group the differences were not statistically significant. Moderate effect size differences for OC and small for NI of the EN-CBM were found at post-test in favour of the Maths Recovery group.

Another encouraging outcome is that the gains that the intervention group made at post-test were maintained seven months after the end of the intervention period, demonstrated by the follow-up test on the TEMA-3.

An important methodological strength of the present study was the random allocation of participants into the two groups and testing at pre and post-test blind to intervention group status. Employing this design in an applied setting such as a special needs school was made possible by the support of school personnel and the children's parents who were highly interested in our investigation of a numeracy curriculum. No parent objected to their child's participation in the project even though it was understood that only half of the children would be receiving intervention during the research period. The headteacher of the school welcomed our suggestion to conduct the study, and teaching staff members were supportive and willing to cooperate with us throughout the different stages of the project (e.g., by attending training meetings, delivering the one-to-one teaching, recording data).

The present study also has a number of limitations. Adherence to the proposed level of intervention intensity (3 to 4 sessions per week) was not possible. In a large special needs school setting events such as school outings, staff training sessions, or a child in the classroom requiring extra attention, often resulted in the teaching assistants being unable to find the necessary time to implement the Maths Recovery intervention. As a consequence, intervention intensity was varied across participants in the intervention group. We did explore the correlation between the number of sessions a child had received and the improvement he/she made at post-test. However, there was no meaningful association found. Factors other than intensity may play an important role in the intervention outcome. For example, it is possible that there were IQ level differences between the two groups of children. However, we did not have any information on IQ or Adaptive Behaviour scores. Access to more detailed information on participant characteristics might enable future studies to determine which children are more likely to benefit from individualized intervention. The analysis of individual child data demonstrated that the largest gains were made in the Maths Recovery group by the children with ASD. The association between autism diagnosis and outcomes requires further attention in future research.

A further limitation of the present study was that although diagnosis was one of the randomization criteria, the number of children with ASD was not balanced across the intervention and control groups by the end of the study. At the time of randomization, three children with ASD were allocated to the Maths Recovery group and two to the control group. During the course of the research, an additional child in the intervention group was diagnosed with ASD. Furthermore, we had been given mistaken information by the school regarding another child's diagnosis at the beginning of the study. This child, also allocated to the Maths Recovery group, actually had an ASD diagnosis. At the time of analysis, and after the loss of one child with ASD from each group due to testing difficulties, there were four children with ASD in the intervention group and only one in the control group. As reported above, we conducted an analysis of the data excluding the children with autism and the differences between the groups on the TEMA-3 test remained statistically significant in favour of the intervention group.

We also did not assess treatment fidelity across the different members of staff who delivered the intervention. Due mainly to the fact that the first author was herself daily involved with teaching, the times when a teaching assistant was observed during a session were limited to instances when a problem was reported with a specific child. The fact that teaching staff in special needs schools are not familiar with ABA teaching methodologies increases the possibility of inconsistency in the quality of intervention delivery. For future studies, especially if the intervention is to be implemented with larger numbers of participants, a higher level of support, supervision and fidelity checks will be needed.

Despite the limitations, we believe that the present study contributes to the existing body of research on mathematics interventions with children with severe ID and has some important implications for researchers and practitioners working in this area. We have demonstrated that it is possible to conduct studies with strong experimental control such as randomized controlled trials, within applied educational settings. Implementation of an individualized intervention in a non-ABA context and without the use of additional funding resources also proved feasible. However, this was partly due to the relatively small number of children who received the intervention. For future, larger scale intervention implementation, additional resources would be needed. We would recommend that one member of teaching staff in the school receives relevant training and is given the necessary time to serve as a consultant for the program, taking on tasks such as: providing training and supervision to other members of staff, troubleshooting individual children's programs, and creating and organizing teaching materials .

Outcomes of the present study support previous research findings regarding the importance of systematic instruction when teaching mathematical skills to children with severe ID (Browder et al., 2008). We used a highly structured teaching approach which included specified and measurable goals, systematic use of prompting and prompt-fading procedures, generalization training, and data collection in every session. Furthermore, the Maths Recovery curriculum is well structured and systematic with numeracy targets organized both horizontally (different groups of activities within the same ability level – key topics) and vertically (progressive stages of difficulty). We suggest that both the teaching methodology and the curriculum content need to be well structured for a mathematics intervention to be effective.

In their discussion document on the development and evaluation of complex interventions (MRC, 2008), the Medical Research Council suggest a sequence of stages: (a) identification of the intervention components, (b) an exploratory phase of one or more pilot trials, (c) definitive evaluation employing study designs with appropriate statistical power, (preferably a randomized controlled trial - RCT), and (d) long-term implementation in a non-research environment. In line with this model, we identified Maths Recovery as an early numeracy curriculum that could potentially be used with children with developmental disabilities, and we then conducted a small pilot study with six children with autism in an ABA setting (Chapter 3) which yielded positive results. The present pilot RCT provides some evidence that the adapted Maths Recovery numeracy curriculum can be effective leading to meaningful improvements in the skills of children with ID. We also tested procedural components that would be needed in a definitive RCT (e.g., randomization, teaching procedures, outcome measures, longer term follow-up). However, the intervention was implemented over a relatively short period, with a limited range of outcome measures (e.g., we did not test impact on functional day-to-day numeracy skills), without an alternative mathematics curriculum as a comparison intervention, and without measures of intervention integrity. Thus, further RCT studies are needed to develop the evidence base for the Maths Recovery intervention with this population.

Chapter 6: General Discussion

The present thesis has attempted to expand existing knowledge on effective school-based educational practices for children with autism spectrum disorder (ASD) and/or intellectual disability (ID). Two main areas have been explored: (a) the development of social skills, and (b) the formulation of appropriate curricula and teaching methodologies to teach academics to these children. Effective strategies and materials for both of these important areas of education are very much needed (Strain & Schwartz, 2001).

Within the domain of social skills, an area that has been suggested might play a pivotal role in the overall development of children with ASD was targeted in the two empirical studies that comprise Chapter 2: verbal initiations towards peers. The approach we investigated, the use of a tactile prompting device that cued the child with autism to approach a peer and verbally initiate, had previously been used in two published studies (Shabani et al., 2002; Taylor & Levin, 1998). The present thesis successfully replicated and further refined this method by introducing a more systematic training phase and incorporating the use of prosthetic reinforcement throughout the intervention period. More importantly, we successfully faded the use of all additions to the environment, by gradually removing first the tactile prompt and then the prosthetic reinforcement while maintaining a high rate of verbal initiations.

The next three chapters of the present thesis explored the area of teaching academics, and more specifically, mathematical skills to students with ASD or ID. Chapter 3 of this thesis was concerned with a systematic exploration of the existing literature on mathematical interventions with children with ASD. Sixteen relevant studies were located. Only six of these studies were specifically designed to teach one or more mathematical skills to students with ASD. The remaining 10 studies either included students without autism (typically developing or with a different diagnosis) or targeted non-mathematical as well as mathematical skills. Each of these two categories was reviewed separately. The majority of the studies reported positive findings for the students with ASD. The methodological strength of the reviewed studies was measured based on the Scientific Merit Rating Scale (National Autism Center, 2009). Of the different mathematical interventions evaluated in the reviewed studies only one was used in three different projects, the use of touch-points to teach addition and subtraction skills. All three studies had a good level of methodological quality and reported positive results. Therefore this intervention can be deemed as exceeding the *emerging* stage of evidence although it still needs additional evidence before it can be characterised as *established* (National Autism Center, 2009). This systematic review found that certain mathematical areas (e.g., geometry, data analysis) have not been targeted in published research. Another conclusion was that there is a shortage of comprehensive mathematical curriculums for use with children with autism; interventions described in the included studies targeted one or two isolated mathematical skills.

In Chapter 4 Maths Recovery, a numeracy curriculum originally designed for typically developing children who were performing below the age-appropriate level in mathematics (Wright et al., 2006a), was adapted for use with children with ASD enrolled in ABA programs. The adaptations targeted issues like the simplification of verbal instructions, breaking complicated tasks into smaller steps, the inclusion of prompting and prompt- fading strategies and the addition of a generalization step for each of the lessons. A pilot study was then conducted in the Westwood ABA class with six children with ASD who received individualised numeracy teaching with the adapted Maths Recovery curriculum. Pre- and post- intervention tests revealed that after 20 weeks of intervention all six children improved their numeracy scores.

In Chapter 5 a second evaluation study of the Maths Recovery curriculum was presented. This was a pilot RCT study that included children with ID as well as ASD and was conducted in a non-ABA environment. Twenty-four children with an ID or ASD diagnosis were randomly allocated into the intervention (Maths Recovery) and control (mathematics as usual) groups. At the end of the 12-week intervention period comparisons of pre- and post-test scores of the two groups revealed significant differences in favour of the intervention group on a standardized numeracy measure.

The two studies presented in Chapters 4 and 5 of the present thesis are the first projects to have evaluated the Maths Recovery curriculum with children with intellectual and developmental disabilities; (all previously published research has been conducted with typically developing children). They are also among the first studies that have evaluated a comprehensive mathematical curriculum with this population.

An important element of the present thesis is that both the social skills and the mathematical intervention studies were conducted across different types of educational settings. Study 1 of the tactile prompt project was conducted in the Westwood ABA class whereas in Study 2 the intervention phases with the two participants were conducted in a mainstream school and an Out-of-school-club respectively, and the training phase during home ABA sessions. The Maths Recovery studies were conducted in the Westwood ABA class and in a special needs school that served children with ASD and/or ID. This was to some extend the result of a change of circumstances rather than the original plan at the beginning of the research project. However, the fact that the interventions described in the present thesis were shown to be effective not only in a school setting with a high staff-to-students ratio but also across different school environments is an important finding. Children with ASD/ID are being educated in diverse educational settings worldwide, often under less than optimal conditions and for research to be relevant to practitioners interventions need to be tested in “real world” settings.

Methodological limitations of the current research

The research projects included in the present thesis have added to the existing knowledge on educational practices for children with ASD and/or ID; they do however have a number of weaknesses.

In the Maths Recovery study conducted in the Westwood ABA class an A-B design was used; this was not a strong methodological design. Using a quasi-experimental control group design, with children enrolled in another ABA school setting participating in the control group would have allowed for a higher methodological quality; however this did not prove possible in practice.

Another weakness of the same study is the very small percentage of teaching sessions (5%) that we were able to collect treatment fidelity data. This was partly due to the fact that unlike group teaching formats – whether in regular education or in special education classes- within ABA-based programs the therapist does not use a set timetable for the different areas he/she teaches (e.g., English: 9.00-10.00; Mathematics: 11.00-11.45). Instead, the pupil works on tasks from each area (e.g., language, academic skills, play skills) for short periods throughout the day; working on mathematics was therefore conducted during short sessions (e.g., 5 minutes at a time) throughout the whole school day. This meant that it was not easy to arrange observations.

The Maths Recovery RCT study (Chapter 5) was also weak in this area as we were unable to collect any treatment fidelity data. In the special needs school environment where this study was conducted, apart from the issue of the teaching timetable which was not stable (i.e., the teaching assistants often had to vary the time they taught the children with Maths Recovery due to various classroom issues), an additional difficulty was the shortage of available time for supervision purposes. I was the only person who had the necessary expertise to supervise the teaching assistants, and the majority of my time was taken up by delivering individualised teaching to pupils. Consequently the amount of time I was able to devote to supervisory work was limited. According to the Scientific Merit Rating Scale (National Autism Center, 2009) we used to evaluate methodological strength in the studies we reviewed in Chapter 4, treatment fidelity should be measured for 25% of sessions at a percentage exceeding 80% for the study to be given a score of 5 (indicating strong scientific merit). This is therefore an important area that should be addressed in future research. Videoing teaching sessions could possibly help future researchers to overcome difficulties in this area.

Another limitation of the RCT study involves the fact that we were unable to use the standard score of the main standardized test (TEMA-3, Ginsburg & Baroody, 2003), the Math Ability score. The test has been standardized for typically developing children aged 3 years to 8 years 11 months; many of our participants were of an older chronological age and the Math Ability score could not be calculated for them. We used therefore only the raw scores and the Age Equivalent (mathematical age) scores the TEMA-3 yields. Ginsburg and Baroody (2003) advice that some caution should be exercised when using the mathematical age scores. Despite this limitation and in the absence of any standardized mathematical tests specifically designed for children with intellectual and developmental disabilities, we found this test to be the most appropriate as it is a detailed numeracy skills test that can be used with children across different levels of abilities.

Additional limitations of the RCT study were the relatively short duration of the intervention period (12 weeks), the fact that intensity of intervention varied across children of the Maths Recovery group, and the unequal numbers of children with ASD and ID across the intervention and control groups.

Implications for future research

In this section we will consider ways that the two main areas investigated in the present research, (a) the use of a tactile prompt to increase the verbal initiations of children with autism towards their peers, and (b) the evaluation of the adapted Maths Recovery curriculum with children with ASD and/or ID, can be extended in the future.

A. Social interventions for children with autism

The present evidence base for the use of the tactile prompt to increase the rate of verbal initiations of children with ASD during free-play activities with typically developing peers has been strengthened by the findings of this thesis. Four studies in total have reported positive findings with all 9 participants. These are promising results of a relatively simple, unobtrusive and easy to implement prompting method. Within the complex area of social interactions however, there is still a number of issues that need further investigation. In regards to this particular intervention, an important element that needs to be examined is its longitudinal effectiveness. Considering the severity of the social skills impairments in persons with ASD it is possible that with time the gains the children make with this intervention might decrease. Future projects could include additional follow-up tests and possibly implement additional intervention stages depending on the results. Another important aspect that needs attention and can be examined in future research is the generalization of the intervention effects across different environments and peer groups (e.g., the target child's verbal initiations towards his/her siblings at home). As children with ASD have generalization difficulties, it is possible that some additional training might be needed for an increased rate of initiations across multiple social contexts.

Other findings of the present research, apart from the frequency of initiations, involve the overall quality of the social interactions between the target children and their peers. The transcript data indicated that the target children's quality of initiations improved during the course of the intervention, however they were at times awkward. Additionally, the rate of peers' responses to the target children's initiations was not high. These findings show the serious underlying difficulties children with autism often have in the area of social interactions and point towards the need for further improvement of interventions. Although we taught the children a number of phrases they could use to initiate to their peers, the primary aim of the tactile prompt intervention was to help increase the initiation rate and therefore does not fully address all aspects of social interaction difficulties. Possibly in future studies the tactile prompt intervention could be part of a social skills training "package" which would include a more systematic teaching of reciprocal peer interactions and thus better address the overall quality as well as the rate of interactions.

B. Mathematical interventions for children with ASD and/or ID

In regards to the evaluation of the adapted Maths Recovery curriculum for children with ASD and/or ID, the two studies included in the present thesis have accomplished certain of the stages defined by the MRC complex interventions framework (Medical Research Council, 2008). Our results indicated that the program can be effectively used with both groups of children (i.e., ASD and ID) and that it can be implemented in ABA and in non-ABA environments. We have also provided some answers to questions related to other procedural issues such as the possibility of conducting randomized trials within school environments, the effectiveness of teaching procedures, and the resources needed for larger-scale implementation.

There are still many issues that need to be addressed by future research. The present data base is still small – 18 children in all have received individualized teaching with the adapted Maths Recovery curriculum in the two studies included in the present thesis. Evaluation by larger scale studies is necessary.

The duration of our studies was relatively short – 20 and 12 weeks respectively. To better evaluate the curriculum more longitudinal studies should be conducted; for example evaluating the progress of the children after implementing the curriculum for a whole academic year would probably allow for drawing firmer conclusions.

Another consideration is that the majority of the children treated so far were working on tasks from the Emergent stage of Maths Recovery (e.g., numbers 1 - 20, numerals 1 – 10, counting up to 20 items). Consequently some of the more advanced stages of the curriculum such as the Counting-On stage (e.g., counting in 2s, 5s, 10s, numerals up 1000, adding and subtracting by tens) and the Facile stage (e.g., counting by 10s and 100s, 2-digit additions and subtractions, advanced multiplication and division) have not been evaluated in our studies. Future projects could conduct separate analyses of the effectiveness of the program with beginning, intermediate and advanced learners.

In the RCT study (Chapter 5) we compared the progress of children taught with Maths Recovery to that of children who received “mathematics as usual” teaching. As the information on the exact nature of what consists “mathematics as usual” is rather vague, conducting future projects using a comparison group taught with a different mathematical curriculum might lead to a more convincing argument in favour of Maths Recovery. Another possible argument is that there is no way of assessing whether the post-intervention gains should be attributed to the curriculum itself or to the individualized teaching. Studies that use a comparison group that does receive individualized mathematical teaching (e.g., within an ABA school setting) will provide convincing answers to this question.

An additional direction for future evaluation studies on Maths Recovery is using more homogenous groups of participants (i.e., with an ASD or ID diagnosis only, instead of mixed groups), or have more balanced numbers of participants with each diagnosis within each group.

Practical implications of the present research: applying acquired knowledge in the context of a Greek special needs pre-school

In this section ways that the overall knowledge acquired throughout my studies – not just the PhD research itself – can be applied in my current work setting will be examined. At the time of the writing of this chapter I have been working for approximately one and a half month in a special needs pre-school in the suburbs of Athens. Five children are enrolled in my class: three of them are 6 years of age and have been diagnosed with different degrees of intellectual disability; additionally, two of these children have language difficulties and the third has behavioural problems. The remaining 2 children are 4 years old and have an ASD diagnosis. They are both non-verbal and have very few skills. Generally the children come from families with a low socio-economical background and with the exception of one child with ASD they do not receive educational services (e.g., speech and language therapy) outside of the pre-school.

The greatest challenge I face in my work in this setting involves the difficulty of allocating individualised time to each of the children. In Greek special needs schools there are usually 6 to 7 children per classroom. However, the number of teaching assistants working in the schools is very small; in my school there are 2 teaching assistants in a school with a total of 45 students (40 elementary school children and my 5 pre-school children). Consequently, for the majority of the school day the teacher is the only adult in the class. In these circumstances it is possible to work individually with each child for only short intervals (e.g., 10 – 15 minutes at a time). Therefore I am incorporating the basic elements of the behavioural model of education described in Chapter 1 (i.e., skills assessment, task analysis, reinforcement, prompting and prompt-fading procedures, functional analysis of problem behaviours); however individualised teaching is conducted in a non-intensive format.

Skills assessments based on the ABLLS (Partington & Sundberg, 2006) are ongoing with all the children in my class at this point. Certain teaching targets have been chosen for each child based on the parts of the ABLLS that have been completed, as well as on behavioural teaching manuals for children with ASD (Leaf & McEachin, 1999; Maurice et al., 1996) and we are working daily on them. Individual programs vary; for one of the more advanced children, language targets include the expressive identification of verbs/actions using the correct grammatical form (i.e., use the forms of the verb that indicate singular/plural). For example, the child is shown a picture of two people who are cooking and is asked “what is happening?” The target is for her to say “they are cooking” as she often makes mistakes and might say “he is cooking”. With another child who has good receptive language skills (i.e., can identify at least 100 items, can identify verbs) but only uses a very limited vocabulary of single words many of which are in a “baby language” form, we are working on targets suggested by the speech and language therapist of the school to help him with the production of the basic sounds and sound combinations. For one of the younger children with ASD, initial targets include sitting on a chair for a few minutes, imitating actions using items (play a drum, stack 3 blocks, stir a cup with a spoon), and self-help skills (i.e., dressing skills).

Numeracy targets from the Maths Recovery curriculum have also been incorporated in the individualised programs of two of the older children. Current individual targets include verbal counting 1 to 5 (key topic 1), reading number-lines 1 to 3 (key topic 2) and counting collections of up to 5 items (key topic 3). Additionally, counting using fingers of one hand (key topic 5) activities are being conducted during small-group sessions.

Systems of reinforcement are used with all the children. With the 3 older children I am using token systems; when all the tokens have been collected the child exchanges them with a preferred activity (e.g., a computer game, a musical toy). With the younger children with ASD small food items (e.g., Cheerios®, raisins) and physical play (e.g. tickles) are being used at this stage on a continuous schedule (FR 1 ratio).

An element of my PhD research that I find especially useful at this point in my teaching job is the fact that the studies included in the present thesis were conducted in two very different school environments: the ABA Westwood class and the special needs school. The ABA class with the one-to-one staff to child ratio, high level of senior staff expertise, program organisation and staff training was an ideal school environment for the young children with ASD who received intensive individualised teaching (compared to other school settings though less so than home programs) combined with opportunities for social interaction with typically developing children and integration into regular education environments. It was also an environment that offered excellent opportunities for applied learning to practitioners such as myself. In the special needs school where the Maths Recovery RCT study (Chapter 5) was conducted, where the staff-to-children ratio allowed for limited opportunities for individualised teaching, I had an opportunity to put to practice ABA techniques I had learned in the Westwood class. It was especially important that despite the challenges and the limitations, it was possible to implement in that environment a program that involved individualised teaching as the RCT study demonstrated. As the school I am presently working has much in common with the special needs school in North Wales, the positive results of the study conducted in that setting are an encouragement for me. As other special education teachers have discovered, “it is possible to incorporate ABA in any classroom practice” (Grey, Honan, McClean, & Daly, 2005).

Conclusions

In conclusion, the present thesis has demonstrated ways that Applied Behavioural Analytic methodologies can be applied in various domains of the school education of children with autism spectrum disorders and/or intellectual disabilities. An important contribution of the current research is the demonstration that these methodologies can be effectively applied across different educational contexts.

References

Adcock, J., & Cuvo, A. J. (2009). Enhancing learning for children with autism spectrum disorders in regular education by instructional modifications. *Research in Autism Spectrum Disorders, 3*, 319-328.doi:10.1016/j.rasd.2008.07.004

Akmanoglou, N., & Batu, S. (2004). Teaching Pointing to Numerals to Individuals with Autism Using Simultaneous Prompting. *Education and Training in Developmental Disabilities, 39*, 326-336.

Allman, M., Pelphrey, K. A., & Meck, W. H. (2012). Developmental neuroscience of time and number: implications for autism and other neurodevelopmental disabilities. *Frontiers in integrative neuroscience, 6*.doi: 10.3389/fnint.2012.00007

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders (DSM-IV)* (4rth ed.). Washington, DC: American Psychiatric Association.

Anglesea, M. M., Hoch, H., & Taylor, B. A. (2008). Reducing Rapid Eating in Teenagers with Autism: Use of a Pager Prompt. *Journal of Applied Behavior Analysis, 41*, 107 - 111.doi: 10.1901/jaba.2008.41-107

Anson, H. M., Todd, J. T., & Cassaretto, K. (2008). Replacing overt verbal and gestural prompts with unobrtusive covert tactile prompting for students with autism. *Behavior Research Methods, 40*, 1106 - 1110.doi: 10.3758/BRM.40.4.1106

Ault, M. J., Wolery, M., Gast, D. L., Munson Doyle, P., & Eizenstat, V. (1988). Comparison of Response Prompting Procedures in Teaching Numeral Identification to Autistic Subjects. *Journal of Autism and Developmental Disorders, 18*, 627-636.

Ayres, K. M., Lowrey, K. A., Douglas, K. H., & Sievers, C. (2011). I Can Identify Saturn but I Can't Brush My Teeth: What Happens When the Curricular Focus for Students with Severe Disabilities Shifts. *Education and Training in Autism and Developmental Disabilities, 46*, 11-21.

Banda, D. R., McAfee, J. K., Lee, D. L., & Kubina Jr, R. M. (2007). Math Preference and Mastery Relationship in Middle School Students with Autism Spectrum Disorders. *Journal of Behavioral Education, 16*, 207-223.doi: 10.1007/s10864-006-9035-5

Banda, D. R., & Kubina Jr, R. M. (2010). Increasing Academic Compliance with Mathematics Tasks Using the High-Preference Strategy with a Student with Autism. *Preventing School Failure, 54*, 81-85.

Binder, C. (1996). Behavioral Fluency: Evolution of a New Paradigm. *The Behavior Analyst, 19*, 163-197.

Bobis, J., Clarke, D., Wright, R., Clarke, B., Thomas, G., Young-Loveridge, J., & Gould, P. (2005). Supporting Teachers in the Development of Young Children's Mathematical Thinking: Three Large Scale Cases. *Mathematics Education Research Journal, 16*(3), 27-57.

Bracken, B. A. (1998). *Bracken Basic Concept Scale-Revised*. San Antonio, TX: The Psychological Corporation, Harcout Brace and Company.

Browder, D. M., Spooner, F., Ahlgrim-Delzell, L., Harris, A. A., & Wakeman, S. (2008). A Meta-Analysis on Teaching Mathematics to Students With Significant Cognitive Disabilities. *Exceptional Children, 74*, 407 - 432.

Bullock, J., & Walentas, N. (1989). *TOUCH MATH instruction manual*. Colorado Springs: Innovative learning concepts, inc.

Buttler, F. M., Miller, S. P., Lee, K.-h., & Pierce, T. (2001). Teaching Mathematics to Students With Mild-to-Moderate Mental Retardation: A Review of the Literature. *Mental Retardation, 39*, 20-31.

Chiang, H.-M., & Lin, Y.-H. (2007a). Mathematical ability of students with Asperger syndrome and high-functioning autism. *Autism, 11*, 547-556.doi: 10.1177/1362361307083259

Chiang, H.-M., & Lin, Y.-H. (2007b). Reading Comprehension Instruction for Students With Autism Spectrum Disorders: A Review of the Literature. *Focus on Autism and Other Developmental Disabilities, 22*, 259-267.doi: 10.1177/10883576070220040801

Cihak, D. F., & Foust, J. L. (2008). Comparing Number Lines and Touch Points to Teach Addition Facts to Students With Autism. *Focus on Autism and Other Developmental Disabilities, 23*, 131-137.doi:10.1177/1088357608318950

Cihak, D. F., & Grim, J. (2008). Teaching students with autism spectrum disorder and moderate intellectual disabilities to use counting-on strategies to enhance independent purchasing skills. *Research in Autism Spectrum Disorders, 2*, 716-727.doi:10.1016/j.rasd.2008.02.006

Clarke, B., & Shinn, M. R. (2002). *Test of Early Numeracy (TEN)*. Eden Prairie, MN: Edformation Inc.

Clarke, B., Baker, S., Smolkowski, K., & Chard, D. J. (2008). An Analysis of Early Numeracy Curriculum-Based Measurement. *Remedial and Special Education, 29*, 46-57.doi: 10.1177/0741932507309694

Collins, B. C., Hager, K. L., & Galloway, G. (2011). Addition of Functional Content during Core Content Instruction with Students with Moderate Disabilities. *Education and Training in Autism and Developmental Disabilities, 46*, 22-39.

Cooper, J. O., Heron, T. E., & Heward, W. L. (2007). *Applied Behavior Analysis*. Upper Saddle River, New Jersey: Pearson.

Cote, D., Pierce, T., Higgins, K., Miller, S., Tandy, R., & Sparks, S. (2010). Increasing Skill Performances of Problem Solving in Students with Intellectual Disabilities. *Education and Training in Autism and Developmental Disabilities, 45*, 512-524.

Djuric- Zdravkovic, A., Japundza-Milisavljevic, M., & Dragana, M.-P. (2011). Arithmetic Operations and Attention in Children with Intellectual Disabilities. *Education and Training in Autism and Developmental Disabilities, 46*, 214-219.

Donaldson, J. B., & Zager, D. (2010). Mathematics Interventions for Students With High Functioning Autism/ Asperger's Syndrome. *Teaching Exceptional Children, 42*, 40-46.

Eikeseth, S., Smith, T., Jahr, E., & Eldevik, S. (2002). Intensive Behavioral Treatment at School for 4- to 7-Year-Old Children with Autism. *Behavior Modification, 26*, 49-68.

Eikeseth, S., Smith, T., Jahr, E., & Eldevik, S. (2007). Outcome for Children With Autism Who Begam Intensive Behavioral Treatment Between Ages 4 and 7. *Behavior Modification, 31*(3), 264-278.

Eikeseth, S. (2009). Outcome of comprehensive psycho-educational interventions for young children with autism. *Research in Developmental Disabilities, 30*, 158-178.

Eldevik, S., Eikeseth, S., Jahr, E., & Smith, T. (2006). Effects of Low-Intensity Behavioral Treatment for Children with Autism and Mental Retardation. *Journal of Autism and Developmental Disorders, 36*, 211-224.doi: 10.1007/s10803-005-0058-x

Eldevik, S., Hastings, R. P., Hughes, J. C., Jahr, E., Eikeseth, S., & Cross, S. (2009). Meta-Analysis of Early Intensive Behavioral Intervention for Children with Autism. *Journal of Clinical Child and Adolescent Psychology, 38*, 439-450.doi: 10.1080/15374410902851739

Eldevik, S., Hastings, R. P., Jahr, E., & Hughes, J. C. (2012). Outcomes of Behavioral Intervention for Children with Autism in Mainstream Pre-School Settings. *Journal of Autism and Developmental Disorders, 42*, 210 - 220.doi:10.1007/s10803-011-1234-9

Everhart, J. M., Alber-Morgan, S. R., & Park, J. H. (2011). Effects of Computer-Based Practice on the Acquisition and Maintenance of Basic Academic Skills for Children with Moderate to Intensive Educational Needs. *Education and Training in Autism and Developmental Disabilities, 46*, 556-564.

Fienup, D. M., & Doepke, K. (2008). Evaluation of a Changing Criterion Intervention to Increase Fluent Responding with an Elementary Age Student with Autism. *International Journal of Behavioral Consultation and Therapy, 4*, 297-303.

Fletcher, D., Boon, R. T., & Cihak, D. F. (2010). Effects of the TOUCHMATH Program Compared to a Number Line Strategy to Teach Addition Facts to Middle School Students with Moderate Intellectual Disabilities. *Education and Training in Autism and Developmental Disabilities, 45*, 449-458.

Gagnon, L., Mottron, L., Bherer, L., & Joanette, Y. (2004). Quantification Judgement in High Functioning Autism: Superior or Different? *Journal of Autism and Developmental Disorders, 34*, 679-689.

Gardill, C. M., & Browder, D. M. (1995). Teaching stimulus classes to encourage independent purchasing by students with severe behavior disorders. *Education and Training in Mental Retardation & Developmental Disabilities, 30*, 254-264.

Gersten, R., Chard, D. J., Jayanthi, M., Baker, S., Morphy, P., & Flojo, J. (2009). Mathematics Instruction for Students With Learning Disabilities: A Meta-Analysis of Instructional Components. *Review of Educational Research, 79*, 1202-1242.doi:10.3102/0034654309334431

Ghezzi, P. M., & Bishop, M. R. (2008). Generalized Behavior Change in Young Children with Autism. In J. K. Luiselli, D. C. Russo, W. P. Christian & S. M. Wilczynski (Eds.), *Effective practices for children with autism*. New York: Oxford University Press.

Ginsburg, H. P., & Baroody, A. J. (2003). *TEMA-3, Test of Early Mathematics Ability* (3rd ed.). Austin, TX: Pro-ed.

Green, G. (1996). Evaluating Claims about Treatments for Autism. In C. Maurice, G. Green & S. C. Luce (Eds.), *Behavioral Intervention for Young Children with Autism*. Austin, TX: pro-ed.

Green, V. A., Pituch, K. A., Itchon, J., Choi, A., O'Reilly, M., & Sigafoos, J. (2006). Internet survey of treatments used by parents of children with autism. *Research in Developmental Disabilities, 27*, 70-84.

Greenwood, C. R., Walker, H. M., & Todd, N. M. (1981). Normative and Descriptive Analysis of Preschool Free Play Social Interaction Rates. *Journal of Pediatric Psychology, 6*, 343-367.

Grey, I. M., Honan, R., McClean, B., & Daly, M. (2005). Evaluating the effectiveness of teacher training in Applied Behaviour Analysis. *Journal of Intellectual Disabilities, 9*, 209-227.doi: 10.1177/1744629505056695

Griffith, G. M., Fletcher, R., & Hastings, R. P. (2012). A national UK census of Applied Behavior Analysis school provision for children with autism. *Research in Autism Spectrum Disorders, 6*, 798-805.doi:10.1016/j.rasd.2011.10.014

Grindle, C. F., Hastings, R. P., Saville, M., Hughes, J. C., Kovshoff, H., & Huxley, K. (2009). Integrating evidence-based behavioural teaching methods into education for children with autism. *Educational & Child Psychology, 26*(4), 65-81.

Grindle, C. F., Kovshoff, H., Hastings, R. P., & Remington, B. (2009). Parents' Experiences of Home-Based Applied Behavior Analysis Programes for Young Children with Autism. *Journal of Autism and Developmental Disorders, 39*, 42-56.

Grindle, C. F., Hastings, R. P., Saville, M., Hughes, J. C., Huxley, K., Kovshoff, H., Griffith, G. M., Walker-Jones, E., Devonshire, K., & Remington, B. (2012). Outcomes of a Behavioral Education Model for Children With Autism in a Mainstream School Setting. *Behavior Modification, 36*, 298-319.doi:10.1177/0145445512441199

Haring, T. G., Breen, C. G., Weiner, J., Kennedy, C. H., & Bednersh, F. (1995). Using Videotape Modelling to Facilitate Generalized Purchasing Skills. *Journal of Behavioral Education, 5*, 29-53.

Hauk, M., Fein, D., Waterhouse, L., & Feinstein, C. (1995). Social Initiations by Autistic Children to Adults and Other Children. *Journal of Autism and Developmental Disorders, 25*, 579 - 595.

Hess, K. L., Morrier, M., J., Heflin, J. L., & Ivey, M. L. (2008). Autism Treatment Survey: Services Received by Children with Autism Spectrum Disorders in Public School Classrooms. *Journal of Autism and Developmental Disorders, 38*, 961-971.doi 10.1007/s10803-007-0470-5

Holifield, C., Goodman, J., Hazelkorn, M., & Heflin, L. J. (2010). Using Self-Monitoring to Increase Attending to Task and Academic Accuracy in Children with Autism. *Focus on Autism and Other Developmental Disabilities, 25*, 230-238.doi: 10.1177/1088357610380137

Jackobson, N. S., & Truax, P. (1991). Clinical Significance: A Statistical Approach to Defining Meaningful Change in Psychotherapy Research. *Journal of Consulting and Clinical Psychology, 59*, 12-19.

Kamps, D., Locke, P., Delquadri, J., & Hall, R. V. (1989). Increasing academic skills of students with autism using fifth grade peers as tutors. *Education and Treatment of Children, 12*, 38-51.

Kamps, D. M., Leonard, B. R., Vernon, S., Dugan, E. P., Delquadri, J. C., Gershon, B., Wade, L., & Folk, L. (1992). Teaching social skills to students with autism to increase peer interactions in an integrated first-grade classroom. *Journal of Applied Behavior Analysis, 25*, 281 - 288.

Kanner, L. (1943). Autistic disturbances of affective contact. *Nervous Child, 2*, 217-250.

Keintz, K. S., Miguel, C. F., Kao, B., & Finn, H. E. (2011). Using conditional discrimination training to produce emergent relations between coins and their values in children with autism. *Journal of Applied Behavior Analysis, 44*, 909-913.doi: 10.1901/jaba.2011.44-909

Koegel, L. K., Koegel, R. L., Shoshan, Y., & McNerney, E. (1999b). Pivotal Response Interventiion II: Preliminary Long-Term Outcome Data. *Journal of the Association for Persons with Severe Handicaps, 24*(3), 186-198.

Koegel, L. K. (2000). Interventions to Facilitate Communication in Autism. *Journal of Autism and Developmental Disorders, 30*, 383-391.

Koegel, L. K., Singh, A. K., & Koegel, R. L. (2010). Improving Motivation for Academics in Children with Autism. *Journal of Autism and Developmental Disorders, 40*, 1057-1066.doi: 10.1007/s10803-010-0962-6

Koegel, R. L., Koegel, L. K., & McNerney, E. K. (2001). Pivotal Areas in Intervention for Autism. *Journal of Clinical Child and Adolescent Psychology, 30*, 19-32.Retrieved from http://dx.doi.org/10.1207/S15374424JCCP3001_4

Koegel, R. L., & Koegel, L. K. (2006). *Pivotal Response Treatments for Autism*. Baltimore: Paul Brookes Publishing Co.

Krantz, P. J., & McClannahan. (1993). Teaching children with autism to initiate to peers: effects of a script-fading procedure. *Journal of Applied Behavior Analysis, 26*, 121 - 132.

Kroesbergen, E. H., & Van Luit, J. E. H. (2003). Mathematics Interventions for Children with Special Educational Needs: A Meta-Analysis. *Remedial and Special Education, 24*, 97-114.

Leaf, J. B., Sheldon, J. B., & Sherman, J. A. (2010). Comparison of simultaneous prompting and no-no prompting in two-choice discrimination learning with children with autism. *Journal of Applied Behavior Analysis, 43*, 215-228.doi: 10.1901/jaba.2010.43-215

Leaf, R., & McEachin, J. (1999). *A Work in Progress*. New York: DRL Books.

Legge, D. B., DeBar, R. M., & Alber-Morgan, S. R. (2010). The Effects of Self-Monitoring with a MotivAider on the On-task Behavior of Fifth and Sixth Graders with Autism and Other Disabilities. *Journal of Behavior Assessment and Intervention in Children, 1*, 43-52.

Levingston, H. B., Neef, N. A., & Cihon, T. M. (2009). The effects of teaching precurrent behaviors on children's solution of multiplication and division word problems. *Journal of Applied Behavior Analysis, 42*, 361-367.doi: 10.1901/jaba.2009.42-361

Lloyd, J. E. V., Irwin, L. G., & Hertzman, C. (2009). Kindergarten school readiness and fourth-grade literacy and numeracy outcomes of children with special needs: a population-based study. *Educational Psychology, 29*, 583-602.doi: 10.1080/01443410903165391

Lovaas, I. O. (2003). *Teaching Individuals with Developmental Delays*. Austin, TX: Pro-ed.

Machalicek, W., O' Reilly, M. F., Beretvas, N., Sigafoos, J., Lancioni, G., Sorrells, A., Lang, R., & Rispoli, M. (2008). A review of school-based instructional interventions for students with autism spectrum disorders. *Research in Autism Spectrum Disorders, 2*, 395-416.doi: 10.1016/j.rasd.2007.07.001

Matson, J. L., & Shoemaker, M. (2009). Intellectual disability and its relationship to autism spectrum disorders. *Research in Developmental Disabilities, 30*, 1107-1114.doi:10.1016/j.ridd.2009.06.003

Maurice, C., Mannion, K., Letso, S., & Perry, L. (2001). Parent Voices: Difficulty in Accessing Behavioral Intervention for Autism; Working Toward Solutions. *Behavioral Interventions, 16*, 147-165.

Maurice, C., Green, G., & Luce, S. C. (Eds.). (1996). *Behavioral Intervention for Young Children with Autism*. Austin, TX: pre-ed.

McGarrel, M., Healy, O., Leader, G., O'Connor, J., & Kenny, N. (2009). Six reports of children with autism spectrum disorder following intensive behavioral intervention using the Preschool Inventory of Repertoires for Kindergarten (PIRK). *Research in Autism Spectrum Disorders, 3*, 767-782.

McGrath, A. M., Bosch, S., Sullivan, C. L., & Fuqua, W. (2003). Training Reciprocal Social Interactions Between Preschoolers and a Child with Autism. *Journal of Positive Behavior Interactions, 5*, 47 - 54.doi: 10.1177/10983007030050010701

Medical Research Council. (2008). *Developing and evaluating for complex interventions: new guidance*. Retrieved from http://www.mrc.ac.uk/complexinterventionsguidance.

Miller, S. P., Buttler, F. M., & Lee, K.-h. (1998). Validated Practices for Teaching Mathematics to Students with Learning Disabilities: A Review of the Literature. *Focus on Exceptional Children, 31*, 1-23.

Miltenberger, R. G. (2008). *Behavior Modification* (4th ed.). Belmont, CA: Thomson - Wadsworth.

Minshew, N. J., Siegel, D. J., Goldstein, G., & Weldy, S. (1994). Verbal Problem Solving in High Functioning Autistic Individuals. *Archives of Clinical Neuropsychology, 9*, 31-40.

Morris, S. B. (2008). Estimating Effect Sizes From Pretest-Posttest-Control Group Designs. *Organizational Research Methods, 11*, 364-386.doi: 10.1177/1094428106291059

National Autism Center. (2009). *National Standards Report*. Randolph, MA.

National Council of Teachers of Mathematics. (2000). *Principles and Standards for School Mathematics*. Reston, VA.

Nikopoulos, C. K., & Keenan, M. (2003). Promoting social initiation in children with autism using video modeling. *Behavioral Interventions, 18*, 87 - 108.doi: 10.1002/bin.129

Nikopoulos, C. K., & Keenan, M. (2007). Using Video Modeling to Teach Complex Social Sequences to Children with Autism. *Journal of Autism and Developmental Disorders, 37*, 678 - 693.doi 10.1007/s10803-006-0195-x

Odom, S. L., Hoyson, M., Jamieson, B., & Strain, P. S. (1985). Increasing handicapped preschoolers' peer social interactions: cross-setting and component analysis. *Journal of Applied Behavior Analysis, 18*, 3 - 16.

Oke, J. N., & Schreibman, L. (1990). Training Social Initiations to a High-Functioning Autistic Child: Assessment of Collateral Behavior Change and Generalization in a Case Study. *Journal of Autism and Developmental Disorders, 20*, 479-497.

Parks, S. (1992). *Hawaii Early Learning Profile (HELP)*. Palo Alto, CA: Vort Corp.

Partington, & Sundberg. (2006). *The Assessment of Basic Language and Learning Skills - Revised (The ABLLS-R)*. Pleasant Hill, CA: Behavior Analysts.

Patton, J. R., Cronin, M. E., Basset, D. S., & Koppel, A. E. (1997). A Life Skills Approach to Mathematics Instruction: Preparing Students with Learning Disabilities for the Real-Life Math Demands of Adulthood. *Journal of Learning Disabilities, 30*, 178-187.

Peters-Sheffer, N., Didden, R., Korzilius, H., & Sturmey, P. (2011). A meta-analytic study on the effectiveness of comprehensive ABA-based early intervention programs for children with Autism Spectrum Disorders. *Research in Autism Spectrum Disorders, 5*, 60-69.doi:10.1016/j.rasd.2010.03.011

Polychronis, S. C., McDonnell, J., Johnson, J. W., Riesen, T., & Jameson, M. (2004). A Comparison of Two Trial Distribution Schedules in Embedded Instruction. *Focus on Autism and Other Developmental Disabilities, 19*, 140-151.DOI: 10.1177/10883576040190030201

Rapin, I., & Tuchman, R. F. (2008). Autism: Definition, Neurobiology, Screening, Diagnosis. *Pediatric Clinics of North America, 55*, 1129-1146.doi:10.1016/j.pcl.2008.07.005

Reichow, B., & Wolery, M. (2009). Comprehensive synthesis of early intensive behavioral interventions for young children with autism based on the UCLA Young Autism Project Model. *Journal of Autism and Developmental Disorders, 39*, 23-41.

Reichow, B. (2012). Overview of Meta-Analyses on Early Intensive Behavioral Intervention for Young Children with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders, 42*, 512-520.doi: 10.1007/s10803-011-1218-9

Rivera, D. P. (1997). Mathematics Education and Students with Learning Disabilities: Introduction to the Special Series. *Journal of Learning Disabilities, 30*, 2-19, 68.

Rockwell, S. B., Griffin, C. C., & Jones, H. A. (2011). Schema-Based Strategy Instruction in Mathematics and the Word Problem-solving Performance of a Student With Autism. *Focus on Autism and Other Developmental Disabilities, 26*, 87-95.doi:10.1177/1088357611405039

Roid, G. H., & Miller, L. J. (1997). *Leiter international performance scale-revised*. Wood Dale, IL: Stoelting Co.

Sathiyaprakesh, R., Mulloy, A., Lang, R., O' Reilly, M. F., Sigafoos, J., Lancioni, G., Didden, R., & El Zein, F. (2011). Use of computer-based interventions to improve literacy skills in students with autism spectrum disorders: A systematic review. *Research in Autism Spectrum Disorders, 5*, 1306-1318.doi: 10.1016/j.rasd.2011.03.004

Scott, K. S. (1993). Multisensory Mathematics for Children with Mild Disabilities. *Exceptionality, 42*, 97-111.

Shabani, D. B., Katz, R. C., Wilder, D. A., Beauchamp, K., Taylor, C. R., & Fischer, K., J. (2002). Increasing Social Initiations in Children with Autism: Effects of a Tactile Prompt. *Journal of Applied Behavior Analysis, 35*, 79-83.

Skibo, H., Mims, P., & Spooner, F. (2011). Teaching Number Identification to Students with Severe Disabilities using Response Cards. *Education and Training in Autism and Developmental Disabilities, 46*, 124-133.

Smith, T. (2001). Discrete Trial Training in the Treatment of Autism. *Focus on Autism and Other Developmental Disabilities, 16*, 86-92.doi: 10.1177/108835760101600204

Smith, T., Cobb, P., Farran, D., Gordray, D., Munter, C., Green, S., Garrison, A., & Dunn, A. (2010). *Evaluating Math Recovery: Implications for Policy and Practice.* Paper presented at the annual meeting of the Society for Research on Educational Effectiveness, Washington, DC.

Sparrow, S. S., Cicchetti, D. V., & Balla, D. A. (2005). *Vineland Adaptive Behavior Scales, Survey Forms Manual* (2nd ed.). Circle Pines, MN: AGS Publishing.

Steffe, L. P. (1992). Learning Stages in the Construction of Number Sequence. In J. Bideaud, C. Meljac & J. Fisher (Eds.), *Pathways to number: Children's developing numerical abilities*. Hillsdale, NJ: Lawrence Erlbaum.

Strain, P. S., & Schwartz, I. (2001). ABA and the Development of Meaningful Social Relations for Young Children with Autism. *Focus on Autism and Other Developmental Disabilities, 16*, 120-128.doi: 10.1177/108835760101600208

Su, H. F. H. (2002). Project MIND-Math is not difficult. *Journal of Mathematics Education Leadership, 5*, 26-29.

Su, H. F. H., Lai, L., & Rivera, H. J. (2010). Using an Exploratory Approach to Help Children with Autism Learn Mathematics. *Creative Education, 1*, 149-153.doi:10.4236/ce.2010.13023

Sulzer-Azaroff, B., & Mayer, G. R. (1991). *Behavior analysis for lasting change*. Belmont, CA: Wadsworth/Thomson Learning.

Sundberg, M. L. (2008). *VB-MAPP: Verbal Behavior Milestones Assessmen and Placement Program*. Concord, CA: AVB Press.

Swaggart, B. L., Gagnon, E., Jones Bock, S., Earles, T. L., Quinn, C., Smith Myles, B., & Simpson, R. L. (1995). Using Social Stories to Teach Social and Behavioral Skills to Children with Autism. *Focus on Autism and Other Developmental Disabilities, 10*, 1 - 16.

Symon, J. B. G., & Boettcher, M. A. (2008). Family support and participation. In J. K. Luiselli, D. C. Russo, W. P. Christian & S. M. Wilcyznski (Eds.), *Effective Practices for Children with Autism*. New York: Oxford University Press.

Taylor, B. A., & Levin, L. (1998). Teaching a Student with Autism to Make Verbal Initiations: Effects of a Tactile Prompt. *Journal of Applied Behavior Analysis, 31*, 651-654.

Taylor, B. A., Hughes, C. E., Richard, E., Hoch, H., & Rodriquez Coello, A. (2004). Teaching teenagers with autism to seek assistance when lost. *Journal of Applied Behavior Analysis, 37*, 79 - 82.doi: 10.1901/jaba.2004.37-79

Thorndike, R. L., Hagen, E. P., & Sattler, J. M. (1986). *The Stalford-Binet intelligence scale* (4th ed.). Chicago: Riverside.

Tremblay, A., Strain, P. S., Hendrickson, J. M., & Shores, R. E. (1981). Social Interactions of Normal Preschool Children: Using Normative Data for Subject and Target Behavior Selection. *Behavior Modification, 5*, 237 - 253.

Tzanakaki, P., Grindle, C. F., Hastings, R. P., & Hughes, C. J. (2012). How and Why do Parents Choose Early Intensive Behavioral Intervention for their Young Child with Autism? *Education and Training in Autism and Developmental Disabilities, 47*, 58-71.

Vacc, N. N., & Cannon, S. J. (1991). Cross-age tutoring in mathematics: Sixth graders helping students who are moderately handicapped. *Education & Training in Mental Retardation, 26*, 89-97.

Waters, H. E., & Boon, R. T. (2011). Teaching Money Computation Skills to High School Students with Mild Intellectial Disabilities via the TouchMath Program: A Multi-Sensory Approach. *Education and Training in Autism and Developmental Disabilities, 46*, 544-555.

Weiss, M. J., & Harris, S. L. (2001). Teaching Social Skills to People with Autism. *Behavior Modification, 25*, 785 - 802.doi: 10.1177/0145445501255007

Wilczynski, S. M., & Christian, L. (2008). The National Standards Project: Promoting Evidence-based Practice in Autism Spectrum Disorders. In J. K. Luiselli, D. C. Russo, W. P. Christian & S. M. Wilczynski (Eds.), *Effective Practices for Children with Autism: Educational and Behavioral Support Interventions that Work*: Oxford University Press.

Willey, R., Holliday, A., & Martland, J. (2007). Achieving new heights in Cumbria: Raising standards in early numeracy through mathematics recovery. *Educational & Child Psychology, 24*, 108-118.

Wing, L. (1993). The Definition and Prevalence of Autism: A Review. *European Child and Adolescent Psychiatry, 2*, 61-74.

Woodcock, R. W., McGrew, K. S., & Mather, N. (2001). *Woodcock-Johnson IIITests of Achievement*. Itasca, IL: Riverside Publishing.

World Health Organisation. (1993). *International Classification of Diseases (ICD-10).* Geneva: Author.

Wright, R. J., Cowper, M., Stafford, A., Stanger, G., & Stewart, R. (1994). *The Mathematics Recovery project - a progress report: Specialist teachers working with low-attaining* *first-graders.* Paper presented at the 17th annual conference of the Mathematics Education Research Group of Australia.

Wright, R. J. (2003). A mathematics recovery: Program of intervention in early number learning. *Australian Journal of Learning Difficulties, 8*(4), 6-11.doi: 10.1080/19404150309546741

Wright, R. J., Martland, J., Stafford, A. K., & Stanger, G. (2006a). *Teaching Number: Advancing children's skills & strategies* (2nd ed.). London, California, New Delhi, Singapore: Sage.

Wright, R. J., Martland, J., & Stafford, A. K. (2006b). *Early Numeracy, Assessment for teaching & intervention* (2nd ed.). Los Angeles, London, New Delhi, Singapore, Washinghton DC: Sage.

Zanolli, K., Dagget, J., & Adams, T. (1996). Teaching Preschool Age Autistic Children to Make Spontaneous Initiations to Peers Using Priming. *Journal of Autism and Developmental Disorders, 26*, 407 - 422.

Appendices

Appendix 1

Information to participants (Chapter 2)

1a: Information sheet for parents

1b: Research consent form for parents

Appendix 1a

Information Sheet for Parents

Study title

Use of a tactile prompt to increase social initiations in children with autism

Project team

Pagona Tzanakaki, Research student

MSc student, to be named

Richard Hastings, Professor of Psychology

Carl Hughes, PhD, BCBA, Course Director of ABA MSc

This research project is being carried out by Bangor University.

Purpose of the study

One of the difficulties associated with autism is the lack of interest in social interactions. When children with autism find themselves in a group of other children, they often prefer to play alone and usually do not approach their peers to make conversation or invite them to play together. As a consequence, they experience much less interactive play and conversation compared to their peers, something that can limit their social and verbal learning opportunities. There is also the danger that they might face difficulties with socialization later on in their lives. It is therefore important that behaviours such as taking the initiative to talk to a peer or respond when the peer is talking to them be systematically taught at a young age.

In this project we would like to see whether a small vibrating device can be successfully used to help remind children with autism to talk to other children during free play time. The device is small (about 2X2 inches) and can be placed in the child's pocket, so other people around your child will not be aware of it.

Procedures involved

To assess your child's current level of talking to his peers, we will initially observe him during play time with mainstream children; during this first phase the child will not be given any directions on how to interact with his peers.

As a next step, the school personnel who work with your child in the ABA class, will teach him to approach a peer and talk to him (e.g. invite him to play) every time the pager in his pocket vibrates. During the training phase an adult will play the role of the peer.

Once the child is familiar with the vibrating pager, the device will be placed in the child's pocket during free play time with children from the mainstream part of the school. The therapists who normally accompany your child in these activities will be with him and will reward him with tokens if he approaches a peer and talks to him when the pager vibrates. Tokens are usually stickers or little pictures that are attached with Velcro on a token board. They will later be exchanged with activities that your child enjoys (e.g. he will be given a choice of spending a few minutes on the computer, play station, soft play area etc).

After the child has learned to approach other children with the use of the pager, we will remove the vibrating pager for a few days to observe how the child's behaviour will change as a result (e.g. we expect that talking to peers will be reduced) and we will then reintroduce the vibrating pager. The purpose of this (removal-reintroduction of the device) is to ensure that any changes we see in the child's behaviour are a result of the intervention and not of some other factor.

During the final phase of the experiment we plan to start "fading" the frequency of the vibrations slowly and the hope is that this will then help your child to initiate play activities without the prompt.

Throughout all the phases described above sessions will take place 3-4 times per week, once a day, and last 10 minutes each. During these sessions we will be observing your child and taking data on his behaviour of taking the initiative to talk to another child or responding to another's initiation.

The expected duration of the whole procedure is about 3 months.

What are the benefits of taking part?

With this research project we hope to identify a simple method that will help to increase children's level of initiations to their peers. A benefit of the method is that it does not draw attention to the child and does not make him stand out among other people around him.

Are there any risks involved?

We do not believe that the children participating in the study are being put in risk in any way. As mentioned before, the vibrating device is small and it is unlikely that it will cause any distress to the children. They will also have the chance to gradually get used to it in the training sessions. Your child's identity will be protected at all times and the completed study will not include their name, the name of the school, or any other identifying information.

Your participation is completely voluntary and you reserve the right to withdraw your child from the study at any time without giving any explanations and without this affecting his/her education in any way. If you have any further queries about the study please do not hesitate to contact us, our details are below.

Pagona Tzanakaki

Postgraduate Research Student

The ABA Class
Westwood Primary School
Tabernacle Street
Buckley, Flintshire
CH7 2JT

Email: psp8ab@bangor.ac.uk

Tel: 01244 545731

Or, you may contact the supervisors directly:

Professor Richard Hastings/ Dr Carl Hughes

School of Psychology
Adeilad Brigantia
Penrallt Road
Gwynedd LL57 2AS

Email: r.hastings@bangor.ac.uk, c.hughes@bangor.ac.uk

If you have any complaints about how this study is conducted please address these to:

Professor Oliver Turnbull

Head of School of Psychology

Bangor University

Gwynedd

LL57 2DG

Appendix 1b

Research Consent Form for Parents

Please complete the following and circle as necessary:

1. Have you read the information on the Information sheet? YES / NO

   Have you had an opportunity to ask questions and discuss this study? YES / NO

   Have you received satisfactory answers to all your questions? YES / NO

2. Do you give consent for your child to participate in the study? YES / NO

3. Are you aware that you can withdraw your child from the study at any time without giving a reason for withdrawing? YES / NO

4. Would you like a copy of this consent form? YES / NO

5. Would you like to be sent a copy of the study or, if it is published, a copy of the printed article? YES / NO

Signature____

Date____

Your name ____

Your child's name ____

Address____

____

____________________________Postcode__________________________________

Please return this form, at your earlier convenience, to Pagona Tzanakaki at the ABA Class in Westwood School.

Appendix 2

Manual for the training phase of the tactile prompt project

Teaching Plan Stage one	**Familiarization with tactile prompting devise (motivaider)**

Medium Term Objective: Child will not show any visible signs of distress when a vibrating motivaider devise vibrates in their pocket

Materials: Motivaider, child's file, data sheets, reinforcers

Teaching Procedure:

<u>Frequency of training</u>

If the child is immediately not distressed by the motivaider (i.e., they probe correct at the highest vibration setting with their hand on top of the motivaider on the table and then with the motivaider being in their pocket) then move straight away onto Stage Two. If needed, and the child is initially distressed, conduct at least two training sessions a day, each lasting approximately 5 minutes, and follow the procedure below:

1. Determine reinforcement

Ask the child what they would like to exchange their tokens for at the end of the session (in keeping with how you usually do in your session). Use stimulus preference assessments if necessary.

2. Set the device- Set the vibrating devise to buzz at 30 second intervals (VI schedule). Initially start with the highest vibration setting

SD1: "Lets practice using this buzzer, it will buzz every now and then" (<u>put on table and child's hand on top of it</u>) and set to vibrate at VI 30 sec intervals). "See it vibrates and makes a buzzing noise".
SD2: Lets practice using this buzzer now in your pocket (<u>put in child's pocket with child's hand on top).</u>
SD3: Now lets put it in your pocket (<u>put in child's pocket, hand out of pocket).</u>

For each step reinforce the child for tolerating the vibration (even if they are initially agitated). By pairing the sensation with reinforcement the vibration will become less aversive to them. Gradually fade this procedure so you reinforce with tokens only those trials where the child remains calm.

Prompting Suggestions:

(1) If the child appears distressed with the motivaider initially set to the highest setting, adjust the setting on the motivaider to the lowest setting. There are five settings which gradually increase the strength of the vibration. Work through the different settings
(2) If the child appears distressed model that it is ok, and provide reassuring comments (e.g., "See it doesn't hurt, it just buzzes a bit. Now, you have a turn")
(3) Have favourite toy characters hold the motivaider and provide similar reassuring comments. Then provide child with opportunity to have a turn.

Data Collection:

On the trial by trial data sheet:

*Correct Response***:** Shows no response or no adverse reaction to the motivaider

*Incorrect Response***:** Appears distressed or upset by the motivaider devise (e.g., quickly takes hand off when it vibrates, pushes/ throws the devise away, mands for it to be taken away- “Stop it”, “I don’t like it”, etc)

On the skills tracking sheet: Record the date each target was introduced and mastered.

Mastery Criterion: Using trial by trial data, two consecutive trials for each stage (i.e., buzzer on table child’s hand on top, buzzer in pocket, etc) with no visible signs of distress.

Teaching Plan Stage Two	**Motivaider on table- child's hand on top**

Medium Term Objective: With rule card on the table in front of they child, they will ask a different question each time the devise vibrates when the motivaider is on the table and their hand is placed on top

Materials: Motivaider, child's file, data sheets, rule cards, tokens and token board, reinforcers

Frequency of training: Conduct two training sessions a day, each lasting approximately 10 minutes. This could be broken up into smaller segments if required. You should aim to do at least 20 trials each day. If the child masters this stage in one session, introduce the next stage in the same day. Try to get through the training stages as quickly as possible. This may mean that you master a few stages in one day

<u>Teaching Procedure</u>

1. Determine reinforcement

Ask the child what they would like to exchange their tokens for at the end of the session (in keeping with how you usually do in your session). Use stimulus preference assessments if necessary.

2. Set the device

Set the vibrating devise to buzz at 30 second intervals (FI schedule). This should give enough time to prompt and provide quick reinforcement. If not, discuss with Corinna, Pagona or Maria to adjust the time settings.

3. Child reads rule card

SD1: "Today you will be practicing with me how you can ask your friends questions" (Hand child a rule card). "Let's read what it says on this card"

> I can get tokens for asking my friends questions. I can say:
>
> *Where do you live?*
>
> *When's your birthday?*
>
> *Can I play with you?*
>
> *Do you have any pets?*

R1: Child should read the card, but help with any words that he finds difficult.

4. Child asks questions when cued by the buzzer

Immediately after the child has read the questions on the rule card use most-to-least prompting procedures to teach the child how to ask the questions when cued by the buzzer.

Step one: Prompted trials

SD1: "Lets practice now using the buzzer and asking these questions". (Put the buzzer on the table in front of the child and place the child's hand on top of the buzzer). "Each time you ask me a question from the card I will give you a token"

SD2: When the buzzer vibrates, say "Ask me a question" and simultaneously point to a question on the rule card. Each time you point, point to a different question on the card.

R: Child asks question on the card

C: Nice asking (and give a token), and then provide a quick response to each child's question (Thus, if they say, "Can I play with you?" say "yes, Lets play the tickling game" and give them a quick tickle. Always choose an activity that means that the child can stay sitting down at the table).

If they have asked a social question (e.g., when's your birthday?"), sometimes answer and then repeat the question (i.e., reciprocal social questions), however you are not taking data on this and they do not have to respond (although it would be nice if they did!).

Every five trials present a different rule card that has the questions written on in a different order. Thus, if the child immediately asks all questions correctly and masters the stage then there is no need for a new rule card. However, if they make some errors and need more than five trials to master a stage then you would need to rotate the cards so they see the questions in a different order every five trials.

Step two: Unprompted trials

Keep rule card on the table in front of the child
Fade 'ask me a question' prompts first, followed by pointing prompts, and only provide tokens for unprompted trials. If additional prompts are needed you could "jiggle" the card to draw their attention to it, but this also needs to be faded as soon as possible.

Continue, as above until child asks a different question unprompted for five consecutive trials.

Data Collection:

On the trial by trial data sheet:

Correct Response: Says a different question on the rule card on consecutive trials clearly so that it can be understood. Says a socially appropriate question that is not on the rule card.

Incorrect Response: No response within 3 seconds of vibration; Gives an inappropriate statement or question (e.g., verbal stereotypy; swearing); speaks unclearly so that the question cannot be understood; says the same question on consecutive trials (if they say the same question two or three trials later this is acceptable). Indicate the error made in the margin (NR- no response; IQ- Inappropriate question; US- Unclear speech; Rpt-

Repeated question)

On the skills tracking sheet: Record the date each target was introduced and mastered.

Prompting Suggestions:

(1) Use prompts, as described above, when you first introduce this program
(2) For inappropriate questions- therapist should model an appropriate question
(3) For unclear speech- therapist should say, “Say it clearly” and present an echoic trial (e.g., “Say, What’s your name?”).
(4) For saying the same question on consecutive trials- therapist, should say, “You need to ask a *different* question (and point to a different question on the rule card)”

Mastery Criterion: Using trial by trial data, five consecutive correct trials with no prompts

Teaching Plan Stage Three	**Motivaider in pocket- child's hand on top**

Medium Term Objective: With rule card on the table in front of they child, they will ask a different question each time the devise vibrates when the motivaider is *in their pocket* and their hand is placed on top

Materials: Motivaider, child's file, data sheets, rule cards, tokens and token board, reinforcers

Frequency of training: Conduct two training sessions a day, each lasting approximately 10 minutes. This could be broken up into smaller segments if required. You should aim to do at least 20 trials each day. If the child masters this stage in one session, introduce the next stage in the same day. Try to get through the training stages as quickly as possible. This may mean that you master a few stages in one day

Teaching Procedure

1. Determine reinforcement

Ask the child what they would like to exchange their tokens for at the end of the session (in keeping with how you usually do in your session). Use stimulus preference assessments if necessary.

2. Set the device

Set the vibrating devise to buzz at 30 second intervals (FI schedule). This should give enough time to prompt and provide quick reinforcement. If not, discuss with Corinna, Pagona or Maria to adjust the time settings.

3. Child reads rule card

SD1: "Today you will be practicing with me how you can ask your friends questions" (Hand child a rule card). "Let's read what it says on this card"

> I can get tokens for asking my friends questions. I can say:
>
> *Where do you live?*
>
> *When's your birthday?*
>
> *Can I play with you?*
>
> *Do you have any pets?*

R1: Child should read the card, but help with any words that he finds difficult.

4. Child asks questions when cued by the buzzer

Step one: Unprompted trials

Because of the high levels of prompting in the previous phase of teaching. You will start this training phase with no prompts, but then use prompts if needed following the least to most prompting procedure (see prompting suggestions below).

SD1: "Lets practice now using the buzzer and asking these questions". (Put the buzzer in the child pocket and place the child's hand on top of the buzzer). "Each time you ask me a question from the card I will give you a token"

So that you know when the buzzer has vibrated in the child's pocket start a timer at the same time as the buzzer. Every 30 seconds you would know to prompt the child if no question was forthcoming.

R1: When the buzzer vibrates, child asks question on the card

C: Nice asking (and give a token), and then provide a quick response to each child's question (Thus, if they say, "Can I play with you?" say "yes, Lets play the tickling game" and give them a quick tickle- choose an activity that means that the child can stay sitting down at the table).

If they have asked a social question (e.g., what's your name?"), sometimes answer and then repeat the question (i.e., reciprocal social questions), however you are not taking data on this and they do not have to respond (although it would be nice if they did!).

Every five trials present a different rule card that has the questions written on in a different order. Thus, if the child immediately asks all questions correctly and masters the stage then there is no need for a new rule card. However, if they make some errors and need more than five trials to master a stage then you would need to rotate the cards so they see the questions in a different order every five trials.

Prompting Suggestions:

(1) Use least to most prompts, as described in Stage two (e.g., if 'jiggling' the card to bring their attention to it doesn't work, then point to a question on the card, if this also doesn't work then also use a verbal cue "You need to ask me a question", at the same time as pointing.

(2) For inappropriate questions- therapist should model an appropriate question
For unclear speech- therapist should say, "Say it clearly" and present an echoic trial (e.g., "Say, What's your name?").

(3) For saying the same question on consecutive trials- therapist, should say, "You need to ask a *different* question (and point to a different question on the rule card)"

Data Collection:

On the trial by trial data sheet:

Correct Response: Says a different question on the rule card on consecutive trials clearly so that it can be understood. Says a socially appropriate question that is not on the rule card.

Incorrect Response: No response within 3 seconds of vibration*;* Gives an inappropriate statement or question (e.g., verbal stereotypy; swearing); speaks unclearly so that the question cannot be understood; saying the same question on consecutive trials (if they say the same question two or three trials later this is acceptable)**.** Indicate the error made in the margin (NR- no response; IQ- Inappropriate question; US- Unclear speech; Rpt- Repeated question)

<u>On the skills tracking sheet</u>: Record the date each target was introduced and mastered.

Mastery Criterion: Using trial by trial data, five consecutive correct trials with no prompts

Teaching Plan Stage Four	Motivaider in child's pocket- child's hands on table

Medium Term Objective: With rule card on the table in front of they child, they will ask a different question each time the devise vibrates when the motivaider is *in their pocket* and their hand is not in their pocket (i.e., is on the table).

Materials: Motivaider, child's file, data sheets, rule cards, tokens and token board, reinforcers

Frequency of training: Conduct two training sessions a day, each lasting approximately 10 minutes. This could be broken up into smaller segments if required. You should aim to do at least 20 trials each day. If the child masters this stage in one session, introduce the next stage in the same day. Try to get through the training stages as quickly as possible. This may mean that you master a few stages in one day

Teaching Procedure

1. Determine reinforcement

Ask the child what they would like to exchange their tokens for at the end of the session (in keeping with how you usually do in your session). Use stimulus preference assessments if necessary.

2. Set the device

Set the vibrating devise to buzz at 30 second intervals (FI schedule). This should give enough time to prompt and provide quick reinforcement. If not, discuss with Corinna, Pagona or Maria to adjust the time settings.

3. Child reads rule card

SD1: "Today you will be practicing with me how you can ask your friends questions" (Hand child a rule card). "Let's read what it says on this card"

> I can get tokens for asking my friends questions. I can say:
>
> *Where do you live?*
>
> *When's your birthday?*
>
> *Can I play with you?*
>
> *Do you have any pets?*

R1: Child should read the card, but help with any words that he finds difficult.

4. Child asks questions when cued by the buzzer

Immediately after the child has read the questions on the rule card use least-to-most prompting procedures to teach the child how to ask the questions when cued by the buzzer.

Step one: Unprompted trials

Because of the high levels of prompting in previous phases of teaching. You will start this training phase with no prompts, but then use prompts if needed following the least to most prompting procedure (see prompting suggestions below).

SD1: "Lets practice now using the buzzer and asking these questions". (Put the buzzer in the child pocket and place the child's hands on top of the table "Each time you ask me a question from the card I will give you a token"

If it is easier, or more preferred for the child to have their hands in a different position (e.g., in their lap but still not touching the motivaider) then consult with Corinna, Pagona or Maria. This would be OK, but the important thing is the consistency, everyone should be teaching the same position with the hands.

So that you know when the buzzer has vibrated in the child's pocket start a timer at the same time as the buzzer. Every 30 seconds you would know to prompt the child if no question was forthcoming.

R1: When the buzzer vibrates, child asks question on the card

C: Nice asking (and give a token), and then provide a quick response to each child's question (Thus, if they say, "Can I play with you?" say "yes, Lets play the tickling game" and give them a quick tickle- choose an activity that means that the child can stay sitting down at the table).

If they have asked a social question (e.g., when's your birthday?"), sometimes answer and then repeat the question (i.e., reciprocal social questions), however you are not taking data on this and they do not have to respond (although it would be nice if they did!).

Every five trials present a different rule card that has the questions written on in a different order. Thus, if the child immediately asks all questions correctly and masters the stage then there is no need for a new rule card. However, if they make some errors and need more than five trials to master a stage then you would need to rotate the cards so they see the questions in a different order every five trials.

Data Collection:

On the trial by trial data sheet:

Correct Response: When their hand is not in direct contact with the motivaider, child says a different question on the rule card on consecutive trials clearly so that it can be understood. Says a socially appropriate question that is not on the rule card.

Incorrect Response: Child has hand on the motivaider when they are buzzed; No response within 3 seconds of vibration; Gives an inappropriate statement or question (e.g., verbal stereotypy; swearing); speaks unclearly so that the question cannot be understood; saying the same question on consecutive trials (if they say the same question two or three trials later this is acceptable). Indicate the error made in the margin

(NR- no response; IQ- Inappropriate question; US- Unclear speech; Rpt- Repeated question)

<u>On the skills tracking sheet</u>: Record the date each target was introduced and mastered.

Prompting Suggestions:

(1) Use least to most prompts, as described in Stage two (e.g., if 'jiggling' the card to bring their attention to it doesn't work, then point to a question on the card, if this also doesn't work then also use a verbal cue "You need to ask me a question", at the same time as pointing.
(2) For inappropriate questions- therapist should model an appropriate question
(3) For unclear speech- therapist should say, "Say it clearly" and present an echoic trial (e.g., "Say, What's your name?").
(4) For saying the same question on consecutive trials- therapist, should say, "You need to ask a *different* question (and point to a different question on the rule card)"

Mastery Criterion: Using trial by trial data, five consecutive correct trials with no prompts

Teaching Plan Stage Five	Eye contact when asking questions

Medium Term Objective: With rule card on the table in front of they child, they will look at you each time they ask the question. The motivaider will be in their pocket and the child's hand will not be on top.

Materials: Motivaider, child's file, data sheets, rule cards, tokens and token board, reinforcers

Frequency of training: Conduct two training sessions a day, each lasting approximately 10 minutes. This could be broken up into smaller segments if required. You should aim to do at least 20 trials each day. If the child masters this stage in one session, introduce the next stage in the same day. Try to get through the training stages as quickly as possible. This may mean that you master a few stages in one day

Teaching Procedure

1. Determine reinforcement

Ask the child what they would like to exchange their tokens for at the end of the session (in keeping with how you usually do in your session). Use stimulus preference assessments if necessary.

2. Set the device

Set the vibrating devise to buzz at 30 second intervals (FI schedule). This should give enough time to prompt and provide quick reinforcement. If not, discuss with Corinna, Pagona or Maria to adjust the time settings.

3. Child reads rule card

SD1: "Today you will be practicing with me how you can ask your friends questions" (Hand child a rule card). "Let's read what it says on this card"

> I can get tokens for asking my friends questions. I can say:
>
> *Where do you live?*
>
> *When's your birthday?*
>
> *Can I play with you?*
>
> *Do you have any pets?*

R1: Child should read the card, but help with any words that he finds difficult.

4. Child asks questions with eye contact

Immediately after the child has read the questions on the rule card use most-to-least prompting procedures to teach the child how to ask the questions with eye contact when cued by the buzzer.

Step one: Prompted trials

SD1: "Lets practice now you looking at me when you ask me the questions" (Put the buzzer in their pocket, their hands should not be on top of the buzzer). "Each time you ask me a question and look at me, I will give you a token"

SD2: When the buzzer vibrates, tap the bridge of your nose at the same time as saying "Look at me".

So that you know when the buzzer has vibrated in the child's pocket start a timer at the same time as the buzzer. Every 30 seconds you would know to prompt the child if no question was forthcoming.

R: Child asks question on the card with eye contact

C: Lovely looking (and give a token), and then provide a quick response to each child's question (Thus, if they say, "Can I play with you?" say "yes, Lets play the tickling game" and give them a quick tickle. Always choose an activity that means that the child can stay sitting down at the table).

If they have asked a social question (e.g., when's your birthday?"), sometimes answer and then repeat the question (i.e., reciprocal social questions), however you are not taking data on this and they do not have to respond (although it would be nice if they did!).

Every five trials present a different rule card that has the questions written on in a different order. Thus, if the child immediately asks all questions correctly and masters the stage then there is no need for a new rule card. However, if they make some errors and need more than five trials to master a stage then you would need to rotate the cards so they see the questions in a different order every five trials.

Step two: Unprompted trials

Keep rule card on the table in front of the child. Fade the following prompts:

(1) Change instructional SD from "Lets practice now you looking at me when you ask me the questions" to the SD used in previous stages "Lets practice now using the buzzer and asking these questions"
(2) When the motivaider vibrates fade saying "you need to look at me" then tapping your nose.

Continue, as above until child asks a different question with eye contact unprompted for five consecutive trials.

Prompting Suggestions:

For eye contact

(1) If the child is not looking at you when they ask the question, say, “You need to look at me, when you ask me the question”. If this doesn’t bring about the desired response then lightly tap the bridge of your nose at the same time as saying “you need to look at me”. Fade as soon as possible.
(2) Change the SD above, so you include a cue for looking, (e.g., “Lets practice now using the buzzer and you looking at me when you ask me these questions”
(3) If eye contact continues to be a problem they could be given new rule cards which say “I can get tokens for looking at my friends when I ask questions”

For asking questions

(4) Use least to most prompts, as described in previous stages for the child to ask the questions from the rule card (e.g., if ‘jiggling’ the card to bring their attention to it doesn’t work, then point to a question on the card, if this also doesn’t work then also use a verbal cue “You need to ask me a question”, at the same time as pointing.
(5) For inappropriate questions- therapist should model an appropriate question
(6) For unclear speech- therapist should say, “Say it clearly” and present an echoic trial (e.g., “Say, What’s your name?”).
(7) For saying the same question on consecutive trials- therapist, should say, “You need to ask a *different* question (and point to a different question on the rule card)”

Data Collection:

On the trial by trial data sheet:

Correct Response: Says a different question on the rule card on consecutive trials clearly so that it can be understood and looks at you when they ask the question. Says a socially appropriate question that is not on the rule card with eye contact.

Incorrect Response: Does not look at you when they ask the question, no response within 3 seconds of vibration; Gives an inappropriate statement or question (e.g., verbal stereotypy; swearing); speaks unclearly so that the question cannot be understood; saying the same question on consecutive trials (if they say the same question two or three trials later this is acceptable). Indicate the error made in the margin (NL- no looking; NR- no response; IQ- Inappropriate question; US- Unclear speech; Rpt- Repeated question)

On the skills tracking sheet: Record the date each target was introduced and mastered.

Mastery Criterion: Using trial by trial data, five consecutive correct trials with no prompts

Teaching Plan Stage Six	**Repeating question after non response ("persistence")**

Medium Term Objective: With rule card on the table in front of they child, they will still look at you each time they ask the question. The motivaider will be in their pocket and the child's hand will not be on top. In addition, the child will repeat the question once if you do not answer the question the first time

Materials: Motivaider, child's file, data sheets, rule cards, tokens and token board, reinforcers

Frequency of training: Conduct two training sessions a day, each lasting approximately 10 minutes. This could be broken up into smaller segments if required. You should aim to do at least 20 trials each day. If the child masters this stage in one session, introduce the next stage in the same day. Try to get through the training stages as quickly as possible. This may mean that you master a few stages in one day

Teaching Procedure

1. Determine reinforcement

Ask the child what they would like to exchange their tokens for at the end of the session (in keeping with how you usually do in your session). Use stimulus preference assessments if necessary.

2. Set the device

Set the vibrating devise to buzz at 45 second intervals (FI schedule). The time interval is increased to allow extra time for a non response and for the question to be repeated. This should give enough time to prompt and provide quick reinforcement. If not, discuss with Corinna, Pagona or Maria to adjust the time settings.

3. Child reads rule card

SD1: "Today you will be practicing with me how you can ask your friends questions" (Hand child a rule card). "Let's read what it says on this card"

> I can get tokens for asking my friends questions. I can say:
>
> *Where do you live?*
>
> *When's your birthday?*
>
> *Can I play with you?*
>
> *Do you have any pets?*

R1: Child should read the card, but help with any words that he finds difficult.

4. Child asks questions with eye contact

Immediately after the child has read the questions on the rule card use most-to-least prompting procedures to teach the child how to repeat the question when you do not answer

Step one: Prompted trials- non response every trial

SD1: "Lets practice now you repeating the question when I do not answer" _(Put the buzzer in their pocket, their hands should not be on top of the buzzer). "Each time you ask me a question again, I will give you another token"

So that you know when the buzzer has vibrated in the child's pocket start a timer at the same time as the buzzer. Every 30 seconds you would know to prompt the child if no question was forthcoming.

R1: The child asks you a question when the motivaider buzzes

C/SD2: You still provide a token for the first question but do not respond

Prompt: Wait three seconds, and then say "I didn't answer. You need to ask me the question again" at the same time as pointing to the same question they asked previously

R2: Child asks the question on the card a second time with eye contact

C2: Lovely asking me again (and give a token)

Step two: Unprompted trials- non response every trial

Keep rule card on the table in front of the child
Fade 'you need to ask me the question again" prompts first, followed by pointing prompts, and only provide tokens for unprompted trials.

Continue, as above until child can repeat the question for five consecutive trials when you do not respond first time.

Step three: Intermix trials so that sometimes you respond immediately sometimes you don't

With no prompts child can differentiate between when they need to repeat the same question after you have not answered their question and when they can move onto a different question on the next trial when you answer first time.

Continue, as above until child can answer correctly for ten consecutive trials (i.e., five each of them having to repeat the question versus when they don't have to repeat the question).

Data Collection:

On the trial by trial data sheet:

Correct Response:

For non responses: After your non response to their question they repeat the same question again (with eye contact) within 5 seconds of when they initially asked the question.

Other trials: Says a different question on the rule card on consecutive trials clearly so that it can be understood and looks at you when they ask the question. Says a socially appropriate question that is not on the rule card with eye contact.

Incorrect Response:

For non responses: The child does not repeat any question within 5 seconds of the non response; child asks a different question within the five seconds (i.e., they don't repeat the previous question). Indicate in the margin NP (No persistence) for this error

Other trials: Does not repeat any question after non response; Repeats a different question after the non response; Does not look at you when they ask the question, no response within 3 seconds of vibration; Gives an inappropriate statement or question (e.g., verbal stereotypy; swearing); speaks unclearly so that the question cannot be understood; saying the same question on consecutive trials (if they say the same question two or three trials later this is acceptable). Indicate the error made in the margin (NL- no looking; NR- no response; IQ- Inappropriate question; US- Unclear speech; Rpt-Repeated question;

On the skills tracking sheet: Record the date each target was introduced and mastered.

Prompting Suggestions:

For repeating questions

(1) Use prompts, as described above, when you first introduce this program
(2) It may be useful to have a second person to prompt
(3) It may also be useful to write on the rule card the additional requirement. For example, "I can get tokens for looking at my friends when I ask questions and for remembering to ask again when they don't answer"
(4) If they ask a different question, remind them that it needs to be the same question and point to it on the rule card.

For other trials

(1) See previous stages

Mastery Criterion:
Step two: Using trial by trial data, five consecutive correct trials with no prompts
Step three: ten consecutive correct trials (5 each of when you respond first time versus when you don't respond first time)

Teaching Plan Stage Seven	Generalizing setting

Medium Term Objective: With child in the setting that they will be for the intervention phase (e.g., main school play ground, main hall) child will be able demonstrate all of the previously acquired skills (e.g., asking questions with eye contact, repeating questions) in response to the buzzer. In addition, they will hold the rule card to remind themselves of the questions and will be able to approach the therapist from across the room/playground to make the initiation.

Materials: Motivaider, child's file, data sheets, rule cards, tokens and token board, reinforcers

Frequency of training: Conduct two training sessions a day, each lasting approximately 10 minutes. This could be broken up into smaller segments if required. You should aim to do at least 20 trials each day. If the child masters this stage in one session, introduce the next stage in the same day. Try to get through the training stages as quickly as possible. This may mean that you master a few stages in one day

Teaching Procedure

1. Determine reinforcement

Ask the child what they would like to exchange their tokens for at the end of the session (in keeping with how you usually do in your session). Use stimulus preference assessments if necessary.

2. Set the device

Set the vibrating devise to buzz at 1 min intervals (FI schedule). The schedule has been changed to a fixed interval 1 min schedule to allow time for prompting but also so that it is more in keeping with the next phase of this study.

3. Child reads rule card

SD1: "Today you will be practicing with me how you can ask your friends questions" (Hand child a rule card). "Let's read what it says on this card"

I can get tokens for asking my friends questions. I can say:

Where do you live?

When's your birthday?

Can I play with you?

Do you have any pets?

R1: Child should read the card, but help with any words that he finds difficult.

SD2: Now let's put the card in your pocket. If you forget what to say, you can take the card out of your pocket and read one of the questions

R2: Child puts card in their pocket

4. Child approaches you to ask questions

Immediately after the child has put the card in their pocket. Set the motivaider to a FI 1 minute schedule and put in the child's pocket. Set your timer/ motivaider so you know when to prompt. They should be encouraged to go and play with something in the room, run around the hall (i.e., you should not be next to them and preferably they should be engaged in an activity when the motivaider vibrates even if it is just walking around).

Step one: Prompted trials- therapist standing in the same position

SD1: "Lets practice now using the buzzer and you coming and asking me these questions when I stand here. You can go and play over there (and point to the other side of the room/ playground. Each time you walk up to me and ask me a question from the card I will give you a token".

R1: Child goes to where they have been instructed to play/ stand. Therapist stays where they are.

SD2 (prompted trial): When the buzzer vibrates, say "Come over here and ask me a question" (if necessary, provide further prompts for the child to stand immediately in front of you and to provide eye contact when they ask the question)

R2: Child approaches you and asks question

C: Nice asking (and give a token), and then provide a quick response to each child's question (Thus, if they say, "Can I play with you?" say "yes, Lets play the tickling game" and give them a quick tickle. Always choose an activity that means that the child can stay sitting down at the table).

Other prompting Suggestions:

(1) If the child approaches you but does not ask a question prompt the child to take the rule card out of their pocket and to choose a question from the card. Gradually fade these prompts over successive trials.
(2) If the child approaches you but has incorrect body orientation (e.g., does not face towards you, stands too far away, etc) target this separately. You could, for example, provide a visual marker (e.g., a chalk line) to show the child where they need to stand but this should be gradually faded.
(3) For other errors- see previous stages for prompting suggestions

Step two: Unprompted trials- therapist standing in the same position

Fade 'Come over here and ask me a question' prompts first and then other prompts, until you are only providing tokens for unprompted trials.

Continue, as above until child asks a different question unprompted for five consecutive trials when you stand in the same position in the hall/ play ground

Step three: Unprompted trials- therapist standing in different positions in the hall/ playground

Move to a different position for each trial, so that the child has to scan the room/ playground to find you. Continue, as above until child asks a different question unprompted for five consecutive trials when you stand in different positions in the hall/ play ground

Step four: Generalize persistence (i.e., intermix trials so that sometimes you respond immediately sometimes you don't)

Same as step three, except occasionally do not respond to the child's question. Continue, until child can answer correctly for five consecutive trials (i.e., three each of them having to repeat the question versus two trials when they don't have to repeat the question).

Data Collection:

On the trial by trial data sheet:

Step two and three

Correct response: Child walks across the room/ playground and asks you a question with eye contact when they are standing immediately in front of you. They should not need to look at their rule card for a reminder.

Incorrect response: Child does not approach you to ask question, child asks question but is standing too far away or does not have eye contact. Child needs to use rule card to ask you a question.

Other incorrect responses (as previous stages): Does not look at you when they ask the question, no response within 3 seconds of vibration; Gives an inappropriate statement or question (e.g., verbal stereotypy; swearing); speaks unclearly so that the question cannot be understood; saying the same question on consecutive trials (if they say the same question two or three trials later this is acceptable).

Step four: Persistence

Correct responses- After therapists' non response: After your non response to their question they repeat the same question again (with eye contact) within 5 seconds of when they initially asked the question.

Incorrect responses- For non responses: The child does not repeat any question within 5 seconds of the non response; child asks a different question within the five seconds (i.e., they don't repeat the previous question).

Other incorrect responses (as previous stages): Does not look at you when they ask the question, no response within 3 seconds of vibration; Gives an inappropriate statement or question (e.g., verbal stereotypy; swearing); speaks unclearly so that the question cannot be understood; saying the same question on consecutive trials (if they say the same question two or three trials later this is acceptable).

On the skills tracking sheet: Record the date each target was introduced and mastered.

Mastery Criterion:
Step two: Using trial by trial data, five consecutive correct trials with no prompts
Step three: Using trial by trial data, five consecutive correct trials with no prompts
Step four: Using trial by trial data, five consecutive correct trials with no prompts (i.e., 3

trials repeating question after a non response 2 trials where they do not need to repeat the question).

Teaching Plan Stage Eight	Generalizing person and delaying token delivery

Medium Term Objective: With child in the setting that they will be for the intervention phase (e.g., main school play ground, main hall) child will be able demonstrate all of the previously acquired skills (e.g., approaching adult from across the room to ask question in response to the buzzer) but with an adult who has not been involved with the previous stages of training. In addition, their therapist will 'brief' them before hand about what they are expected to do and 'debrief them' afterwards, including giving them the tokens they have amassed during the training session.

Materials: Motivaider, child's file, data sheets, rule cards, tokens and token board, reinforcers

Frequency of training: Conduct two training sessions a day, each lasting approximately 10 minutes. This could be broken up into smaller segments if required. You should aim to do at least 20 trials each day. If the child masters this stage in one session, introduce the next stage in the same day. Try to get through the training stages as quickly as possible. This may mean that you master a few stages in one day

Teaching Procedure

1. Determine reinforcement

Ask the child what they would like to exchange their tokens for at the end of the session (in keeping with how you usually do in your session). Use stimulus preference assessments if necessary.

2. Set the device

Set the vibrating devise to buzz at 1 min intervals (FI schedule). The schedule has been changed to a fixed interval 1 min schedule to allow time for prompting but also so that it is more in keeping with the next phase of this study.

3. "Briefing" child before session

Briefing Statement

"Today you will be asking (*name of person who does not usually work with child*) these questions (and go through questions with child)

"I can get tokens for asking my friends questions". I can say:

Where do you live?

When's your birthday?

Can I play with you?

Do you have any pets?

I am going to hold onto the card for you, and stand over here and see how well you do remembering to ask XX the questions. Each time I see you ask (XXX) a question and I see you looking and standing close to XXX, I am going to put a token on your board. You will not see me give you a token each time, but at the end, I'll call you over and we can see how well you have done. OK let's start (put the motivaider in child's pocket set to a FI 1 min schedule). Go and play over there and remember to ask XXX the questions when you feel the buzzer *(and child goes to the specified location).*

4. Child approaches adult (not involved in training) to ask the questions.

Step one: Unprompted trials- unfamiliar adult in varied locations in the hall/ playground

Because of the high levels of prompting in the previous phases of teaching. You will start this training phase with no prompts, but then use prompts if needed following the least to most prompting procedure (see below).

SD1: Child is playing/ walking around the room/ playground. Unfamiliar adult is in the same location a few feet away. Therapist is at the side of the room/ playground holding the token board. They have a timer/ motivaider so that they know when the child's devise has gone off to prompt if necessary. Child's motivaider goes off.

R1: Child approaches adult and asks the question

C: Therapist notes the correct response on the data sheet, and puts a token on the token board

Prompting suggestions

All prompts should be delivered by the therapist and not the unfamiliar adult.

(1) If the child does not approach the unfamiliar adult within 5 second of the vibration, the therapist could say from across the room, "remember you need to ask XX questions when you feel the buzz in your pocket"
(2) If the child approaches the adult but does not ask a question, the therapist could quickly show them the question prompt card.
(3) If the child approaches the adult but has incorrect body orientation (e.g., does not face them, stands too far away, etc) target this separately. You could, for example, provide a visual marker (e.g., a chalk line) to show the chills where they need to stand but this should be gradually faded.
(4) For other errors- see previous stages for prompting suggestions

Debriefing statement

After the session (approximately ten minutes) call the child over to debrief them.
"Lets see how well you did. You got (five tokens) for asking XXX questions. Well done!"
*Point out what went well during the session- (*For example) "You really remembered the questions very well, and stood right in front of her when you asked the questions"
*Point out what did not go so well during the session- (*For example) "Sometimes, you forgot to look at her when you asked the question, so I could not give you tokens for

those questions. Try to remember to do that next time".

Data Collection:

On the trial by trial data sheet:

Correct response: Child walks across the room/ playground and asks the unfamiliar adult a question with eye contact when they are standing immediately in front of them. They should not need to look at their rule card for a reminder.

Incorrect response: Child does not approach adult to ask question, child asks question but is standing too far away or does not have eye contact. Child needs to use rule card to ask the question.

On the skills tracking sheet: Record the date each target was introduced and mastered.

Mastery Criterion:
Five consecutive correct trials with no prompts

Appendix 3

Samples of rule cards

3a. Rule card used with Alex and Peter

3b. Rule card used with Reuben

3c. Rule card used with Katie

Appendix 3a

Rule card used with Alex and Peter

I can get tokens for asking my friends questions. I can say:

Do you have any pets?

Where do you live?

Can I play with you?

What’s your favourite TV programme?

When is your birthday?

A buzzer will remind me when to ask a question to a friend.

Appendix 3b

Rule card used with Reuben

I can talk to my friends. When I feel my buzzer I can say:

 “Hello!” and get a token, or...

 “Can we play?” and get a token.

Appendix 3c

Rule card used with Katie

My rule card:

I can get tokens for asking my friends questions. I can say:

Can I play too?

Do you have a Wii?

Do you want to dance like Britain's Got Talent?

Do you watch Horrid Henry?

What's your name?

A buzzer will remind me when to speak to my friend.

Appendix 4

Information to participants (Chapter 4)

4a. Information sheet for parents

4b. Consent form

Appendix 4a

Information Sheet for Parents (Form A)[4]

Study title

An evaluation of the use of the Maths Recovery Program to teach numeracy to children with autism

Project team

Pagona Tzanakaki, Research student

Corinna Grindle, PhD, BCBA, Consultant Behaviour Analyst

Richard Hastings, Professor of Psychology

Carl Hughes, PhD, BCBA, Course Director of ABA MSc

This research project is being carried out by Bangor University.

Purpose of the study

Children with autism – as you are probably aware – often need to be taught in a very structured and systematic way in order to learn. For this reason detailed teaching procedures are being used in ABA programs to teach a variety of skills, e.g. language, play, self-help skills etc. However, in the area of mathematics, a detailed curriculum has not yet been developed. The existing ABA teaching manuals include only a few numeracy targets. We believe that a more systematic numeracy program will be helpful for children with autism in ABA programs and the teaching staff who work with them.

[4] We had planned to use Form B with participants of a control group that would be recruited from other ABA schools, however this did not prove possible; therefore only Form A was used.

The Maths Recovery Program is a detailed curriculum that has been designed to help teach numeracy to young children. It was originally developed in Australia for typically developing children who face difficulties in mathematics and is now being used in many countries around the world, including some schools in the UK. Because Maths Recovery has many characteristics in common with the teaching methods used in ABA programs (e.g. breaking a task into small steps, one to one teaching, etc) we believe that it can be effectively used as the basis of a numeracy curriculum for children with autism.

A number of studies which have already been conducted to evaluate Maths Recovery have shown that it is an effective numeracy program. All these studies have involved typically developing children. Since no research has yet been done with children with autism, we are interested in investigating how these children progress when taught with the program and compare their progress with that of children who are taught with the usual teaching manuals.

Procedures involved

We intend to use two groups of KS-1 and KS-2 children for the purposes of the study. Group A (Westwood School) children will be taught with the Maths Recovery program. (Maths Recovery is already being used in Westwood, both in the mainstream and in the ABA unit but no systematic evaluation has been done yet). Group B (children enrolled in other ABA schools) will continue to be taught with the maths curriculum currently in use by their school. Personnel in the schools have expressed interest in participating in the study, in the condition that the investigators will provide training to staff members on the use of Maths Recovery.

The following procedure will be used:

1. At the beginning of the study children in both groups will complete a few standardized numeracy tests.
2. For the rest of the school year the children of group A will receive systematic numeracy instruction based on Maths Recovery. This will be delivered by the tutors who normally work with each child and will take place during the ordinary school day for approximately 30 minutes (per day).
3. At the end of the school year children in both groups will again be tested using the same standardized tests used in the beginning of the study.
4. To ensure that all tutors implement the teaching procedures correctly, it is possible that some of the teaching sessions might be videotaped. The video tapes will only be viewed by the research team members and will be kept in a secure cabinet until data analysis has been completed. They will be destroyed after that.

We would like to request your child’s participation in group A.

What are the benefits of taking part?

The main benefits of this research relate to improving the knowledge that we have on the best teaching practices for children with autism. Numeracy and mathematical skills in general have been shown to be an important component of success in school and are necessary in almost any vocational environment. But, more importantly, math skills are essential in everyday life activities such as cooking and managing personal finances. Consequently, in any population, including persons with autism, independence is partly determined by competency in math skills. We hope that the results of this study will help professionals working in school- and home-based programmes for children with autism by providing them with a detailed curriculum that can be used with children across a wide range of numeracy skills.

Are there any risks involved?

We do not believe that the children participating in the study are being put in risk in any way. Your child's identity will be protected at all times and the completed study will not include their name, the name of the school, or any other identifying information.

Your participation is completely voluntary and you reserve the right to withdraw your child from the study at any time without giving any explanations and without this affecting his/her education in any way. If you have any further queries about the study please do not hesitate to contact us, our details are below.

Pagona Tzanakaki

Postgraduate Research Student

The ABA Class
Westwood Primary School
Tabernacle Street
Buckley, Flintshire
CH7 2JT

Email: psp8ab@bagnor.ac.uk

Tel: 01244 545731

Or

Dr Corinna Grindle

Consultant Behaviour Analyst

The ABA Class

Westwood Primary School

Tabernacle Street

Buckley, Flintshire

CH 7 2JT

Email: c.grindle@bangor.ac.uk

Tel: 01244 545731

If you have any complaints about how this study is conducted please address these to:

Professor Oliver Turnbull

Head of School of Psychology

Bangor University

Gwynedd

LL57 2DG

Appendix 4b

Research Consent Form for Parents

Please complete the following and circle as necessary:

6. Have you read the information on the Information sheet? YES / NO

   Have you had an opportunity to ask questions and discuss this study? YES / NO

   Have you received satisfactory answers to all your questions? YES / NO

7. Do you give consent for your child to participate in the study? YES / NO
8. Do you give consent for your child to be videoed? YES / NO
9. Are you aware that once research has been completed these video tapes will be destroyed? YES / NO
10. Are you aware that you can withdraw your child from the study at any time without giving a reason for withdrawing? YES / NO
11. Would you like a copy of this consent form? YES / NO
12. Would you like to be sent a copy of the study or, if it is published, a copy of the printed article? YES / NO

Signature____

Date____

Your name ____

Your child's name ____

Address____

____

_______________________Postcode____________________________

Please return this form, at your earlier convenience, to Pagona Tzanakaki at the ABA Class in Westwood School.

Appendix 5

Letter sent to parents to ask for permission for a follow-up test

5a. Information letter

5b. Consent form

Appendix 5a

Information letter

Dear parents

During the previous school year (2009-10) we conducted a study on the use of a Mathematics curriculum called Maths Recovery with young children with autism. Maths Recovery had been shown to help typically developing children who have difficulties in maths and our purpose was to investigate whether it could be effective with children with autism as well.

To be able to measure the progress of the children we tested them with some standardized numeracy tests at the beginning and the end of the teaching period. As you probably remember, we asked your permission at the beginning of the school year to conduct the tests with your child (see the Information Sheet attached to this letter).

The results we have so far are encouraging and suggest that Maths Recovery helps children with autism make good progress in their numeracy skills. However, especially as there have been no previous studies on Maths Recovery and children with autism, we would like to see if the improvements we saw have been maintained after the summer holiday. So we are asking for your permission to repeat one of the tests that your child has previously done. Depending on the child's ability level, testing time will be between 15 and 60 minutes. It can take place either at school or at home.

Thank you

Pagona Tzanakaki

Research student

Tel.: 07901992001

E-mail: psp8ab@bangor.ac.uk

Appendix 5b

Consent Form

Please complete the following and circle as necessary:

1. Do you give consent for your child to be tested? YES/NO
2. Where would you prefer the testing to take place? School / Home

Signature____

Date____

Your name ____

Your child's name ____

Address____

____

__________________________Postcode_______________________

Appendix 6

Sample lesson from the adapted Maths Recovery curriculum for children with ASD

Teaching Plan A2.3	**Emergent-Sequencing Numerals**

Key Topic: Numerals from 1 to 10

Medium Term Objective: Child will be able to put in order (i.e., sequence) numbers 1 to 10

Materials: Number cards 1-10. Black numbers on white card. All numbers to be the same proportion. Numbers to be written as follows: 1 2 3 4 5 6 7 8 9 10

Teaching Procedure:

Step one: For numbers 1-3: Arrange 3 number cards on the table in disarray (i.e., in no particular order or position), establish attending and say to the child “Put in order”. Prompt the child to place the cards on the table in the correct order, from left to right, and reinforce the response. Fade prompts over subsequent trials. Differentially reinforce responses demonstrated with the lowest level of prompting. Eventually, only reinforce correct unprompted responses.

Step two: After the task has been mastered with numbers 1-3 move on to numbers 1 to 4, 1 to 5, 4 to 7, 6 to 9, 6 to 10, 1 to 6, 1 to 8, 1 to 10. Remember to probe the later sequences immediately before introducing a new one. If the child probes correct on first trial then you may not need to formally teach that sequence.

Step three - generalization: When the child has become fluent at using the skill, therapists should start to set up opportunities for generalization training (i.e., when different materials are presented, by different people, in different settings).

- For generalization across stimuli the child could be taught to sequence numbers with different number cards (i.e., different fonts, different colours, different sizes, number cards from a game etc). You could also check to see if the child can put cards in order from top to bottom instead of left to right although this is not necessary for mastery of the skill.
- For generalization across SDs, instructions could include “Put these in the correct order “Sequence these numbers”).

- Present the task in a different setting
- Have a different person present the task

Prompting Suggestions:

(1) Initially a blank grid could be used so that the children have somewhere to place their numbers.
(2) Use positional prompts: Placing the number cards near or adjacent to where they should go (i.e., the numbers are not initially presented in disarray).
(3) Use backward chaining teaching procedures (e.g., for 1-2-3):

Step one: Therapist puts cards 1-2 out in correct order and child is required to bring down number 3 and place next to the 2.

SD: Put in order (therapist points to 1 + 2 saying each number at the same time as she points to it)

R: Child brings down number 3 and places it next to the 2.

C: Therapist labels 3 as child brings it down and delivers praise

Thus, although child is not required to label the numbers as he/ she sequences them, the therapist should still label them.

Step two: Therapist puts card # 1 on the table and child is required to bring down numbers 2 and 3 and position correctly.

All prompts should be faded for mastery of the skill.

Mastery Criterion: 3 consecutive yes probes (across sessions) on first trial data. *Under the direction of the consultant this can be changed to 3 consecutive yes probes across days, across days with a 3 day retention period, or to trial-by-trial data (e.g., 10 consecutive correct responses).* However, before introducing each new number sequence the remaining sequences to be taught must first be probed to see if the child probes correct without being formally taught. It is quite possible that they will acquire the concept before you formally teach all the number sequences.

Fluency: Teaching to fluency will not be required for this skill.

Data Collection:

<u>On the probe data sheet</u>: Always take probe data on the first trial of the session for all current targets. The child should not be prompted for these responses.

Correct Response: Puts numbers in the correct position within 3 seconds of the SD when all numbers have been placed in a random position on the table and there is no grid being used for the child. Once the child has placed the first number card, additional numbers should be placed within one second of each other. The child is *not* required to say the number as they bring it down for mastery of the skill.

Incorrect Response: Puts numbers in incorrect order, does not respond within 3 sec of the SD, places numbers slower than one number every second.

Switch to trial by trial data collection if advised by your consultant

On the skills tracking sheet: Record the date each target was introduced and mastered.

Appendix 7

Information to participants (Chapter 5)

7a. Information sheet for parents

7b. Consent form

Appendix 7a

Information Sheet for Parents

Study title

An evaluation of the use of the Maths Recovery Program to teach numeracy to low-performing KS-1 and KS-2 students with learning disabilities

Project team

Pagona Tzanakaki, Research student

Carl Hughes, PhD, BCBA, Course Director of ABA MSc

Richard Hastings, Professor of Psychology

Corinna Grindle, PhD, BCBA, Consultant Behaviour Analyst

This research project is being carried out by Bangor University.

Purpose of the study

Many children with learning disabilities have difficulty learning maths skills at school even though they receive maths teaching in school. We are carrying out a research project to test whether if children with a learning disability are taught in a more intensive and individualized way, their maths skills can improve.

The Maths Recovery Program is a detailed curriculum that has been designed to help teach numeracy skills to young children. It was originally developed in Australia for typically developing children who face difficulties in mathematics and is now being used in many countries around the world, including some schools in the UK. With this teaching program the child is being taught individually, usually for 30 minutes per day.

We believe that although Maths Recovery was developed with typically developing children in mind, it can also be an appropriate curriculum for children who have a learning disability. One important aspect of the program is that because each child is taught individually, the pace of teaching can be adjusted to the child's abilities and rhythm of learning. So, if the child has difficulty with a task, the teacher can break it into smaller, easier steps, model the appropriate maths skills, spend more time with particular tasks, etc. We have already used the program –with some adaptations – to teach a group of Key Stage 1 children with autism who also had learning disabilities and the results were very encouraging. We now hope to show that children with learning disabilities can also benefit from the Maths Recovery model.

Procedures involved

Your child's class teacher has suggested that (s)he might benefit from some additional structured teaching on maths skills.. We will provide training on Maths Recovery to teaching assistants who work in your child's class so that they can teach the children. Because every child will be taught individually and we can only train a limited number of teaching assistants, we will not be able to offer the Maths Recovery teaching to every child at Ysgol y Gogarth in the current school year. Only one half of the children identified by class teachers will be taught with Maths Recovery this school year, while (if Maths Recovery works well) the other half will start on this teaching in the new school year in September 2011.

Children who do not receive the Maths Recovery teaching in January to July 2011 will continue to receive maths teaching as they normally do in their class.

Once you have given consent for your child to take part in this project, we intend to use the following procedure:

5. At the beginning of the research study, all children will complete a few standardized maths tests.
6. The children will be randomly divided (using a computer programme – like tossing a coin to decide) in two groups:
   Those randomly allocated to the first group will receive numeracy teaching based on Maths Recovery for about six months (January to July). This will be delivered by teaching assistants who work in your child's school and will take place during the ordinary school day for approximately 30 minutes per day. Pagona Tzanakaki, who is a qualified teacher and jointly developed the maths recovery model for children with autism, will be supervising the training of the teaching assistants. It is possible that Pagona might be involved with teaching your child maths skills as well.
   During January to July, children randomly allocated to the second group will receive maths teaching in the same format they were previously taught by the school.
7. At the end of the school year in July, children in both groups will again be tested using the same standardized maths tests used in the beginning of the study.
8. If the tests show that the children of the first group have made more progress at the end of the school year than those from the second group, the second group will start the Maths Recovery teaching after the summer holidays in September 2011.

Since children will be randomly allocated into the two groups, your child might either be in the first or in the second group

What are the benefits of taking part?

The main benefits of this research relate to improving the knowledge that we have on the best teaching practices for children with learning disabilities. Numeracy and mathematical skills in general have been shown to be an important component of success in school and are necessary in almost any vocational environment. But, more importantly, maths skills are essential in everyday life activities such as cooking and managing personal finances. Consequently, in any population, independence is partly determined by competence in math skills. We hope that the results of this study will help professionals working in schools with children with learning disabilities by providing them with a detailed curriculum that can be used with children across a wide range of numeracy ability.

Are there any risks involved?

We do not believe that the children participating in the study are being put in risk in any way. Children in our previous work have very much enjoyed the maths teaching. Your child's identity will be protected at all times and the completed study will not include their name, the name of the school, or any other identifying information.

Your participation is completely voluntary and you reserve the right to withdraw your child from the study at any time without giving any explanations and without this affecting his/her education in any way (unless you ask to stop the Maths Recovery teaching with your child). If you have any further queries about the study please do not hesitate to contact us. Our details are below. Pagona would be happy to meet you at Ysgol y Gogarth to discuss any questions you might have.

Pagona Tzanakaki

Postgraduate Research Student

Ysgol y Gogarth

Ffordd Nant y Gamar

Craig y Don

Llandudno

LL30 1YE

Email: psp8ab@bangor.ac.uk

Tel: 07901992001

Or, you may contact the supervisors directly:

Dr Carl Hughes /Professor Richard Hastings

School of Psychology
Adeilad Brigantia
Penrallt Road

Gwynedd

LL57 2AS

Email: c.hughes@bangor.ac.uk , r.hastings@bangor.ac.uk

If you have any complaints about how this study is conducted please address these to:

Professor Oliver Turnbull

Head of School of Psychology

Bangor University

Gwynedd

LL57 2DG

Appendix 7b

Research Consent Form for Parents

Please complete the following and circle as necessary:

13. Have you read the information on the Information sheet? YES / NO

    Have you had an opportunity to ask questions and discuss this study? YES / NO

    Have you received satisfactory answers to all your questions? YES / NO

14. Do you give consent for your child to participate in the study? YES / NO
15. Are you aware that you can withdraw your child from the study at any time without giving a reason for withdrawing? YES / NO
16. Would you like a copy of this consent form? YES / NO
17. Would you like to be sent a copy of the study or, if it is published, a copy of the printed article? YES / NO

Signature____

Date____

Your name ____

Your child's name ____

Address____

____

_______________________Postcode___________________________

Please return this form, at your earliest convenience, to Pagona Tzanakaki at Ysgol y Gogarth.

Appendix 8

Letter to parents asking for permission for a follow-up test

8a. Information letter

8b. Consent form

Appendix 8a

Information letter

Dear parents

During the previous school year (2010-11) we conducted a study on the use of a Mathematics curriculum called Maths Recovery with young children with learning disability. Maths Recovery had been shown to help typically developing children who have difficulties in maths and our purpose was to investigate whether it could be effective with children with special educational needs as well.

To be able to measure the progress of the children we tested them with some standardized numeracy tests at the beginning and the end of the teaching period. As you probably remember, we asked your permission last year to conduct the tests with your child.

The results we have so far are encouraging and suggest that Maths Recovery helps children with learning disability make good progress in their numeracy skills. However, especially as there have been no previous studies on Maths Recovery and children with special educational needs, we would like to see if the improvements we saw have been maintained over time. So we are asking for your permission to repeat one of the tests that your child has previously done. Depending on the child's ability level, testing time will be between 15 and 40 minutes. It will take place at Ysgol y Gogarth during normal school hours.

Thank you

Pagona Tzanakaki

Postgraduate research student

Ysgol y Gogarth

Ffordd Nant y Gamar

Craig y Don

Llandudno

LL30 1YE

Tel.: 07901992001

E-mail: psp8ab@bangor.ac.uk

Appendix 8b

Consent Form

Please complete the following and circle as necessary:

Do you give consent for your child to be tested? YES/NO

Signature____

Date____

Your name ____

Your child's name ____

Address____

____

_______________________Postcode___________________________

Appendix 9

Randomization protocol

Randomisation Specification Document for Maths Recovery Programme

Status	Version	Date
Draft	2	14/01/2011
Final	2	18/01/2011

North Wales Organisation for Randomised Trials in Health (NWORTH)
Bangor University, College of Health & Behavioural Sciences,
Institute of Medical & Social Care Research, Y Wern, Normal Site, Holyhead Road, Bangor, Gwynedd LL57 2PZ
Telephone: 01248 388095
Email: nworth@bangor.ac.uk
http://www.bangor.ac.uk/imscar/nworth

NWORTH CHIGC

Randomisation brief: An individual based randomisation between intervention and waiting list control within a school based community

Agreed by:	Pagona Tzanakaki and Zoë Hoare on the approved research proposal document
Setting:	School based
Participants:	24
Allocation ratio:	1:1
Intervention:	Maths Recovery vs. Waiting list control
Type:	Block
Stratification variables:	School Class (5 levels) Condition (Autism/SLD)
Method:	Email based randomisation. Template form containing all participant will be emailed to NWORTH and returned with results within one working day
Blinding:	Recipients of confirmation emails will be unblind. Outcome assessors will have no access to the randomisation information.
Confirmation:	Emails to sps001@bangor.ac.uk, psp8ab@bangor.ac.uk, pagonatzanakaki@hotmail.com
Group constraints:	NA
Emergency randomisation procedures:	Block randomisation determined as not time critical and therefore does not require randomisation
Timescale:	Start: Jan 2011 End: Feb 2011
Other information:	Participant ID Participant Initials Participant DOB Consent (yes=proceed) Inclusion criteria met (yes=proceed)

Trial contact Pagona Tzanakaki 07901992001 Email: pagonatzanakaki@hotmail.com
psp8ab@bangor.ac.uk

North Wales Organisation for Randomised Trials in Health (NWORTH)
Bangor University, College of Health & Behavioural Sciences,
Institute of Medical & Social Care Research, Y Wern, Normal Site, Holyhead Road, Bangor, Gwynedd LL57 2PZ
Telephone: 01248 388095
Email: nworth@bangor.ac.uk
http://www.bangor.ac.uk/imscar/nworth

NWORTH
CHIGC

	Name	Position	Signed	Date
Prepared By:	Zoë Hoare	Statistician	ZHoare	18/01/11
Reviewed By:	Yvonne Sylvestre	Statistician	[signature]	18/01/11
Approved By:	Pagona Tzanakaki	Trial researcher		

Email Based randomisation

The process of randomisation will require completion of an excel form containing the fields described below.

When complete with all participants to be randomised this form should be sent to z.hoare@bangor.ac.uk and d.s.hanniscott@bangor.ac.uk . NWORTH will randomise the participants and return the completed form to the designated confirmation email addresses within 1 working day of receipt.

Template form

Participant ID	Class	Condition	Participant Initials	Participant DOB	Consent Given	Inclusion criteria met	Allocation given

North Wales Organisation for Randomised Trials in Health (NWORTH)
Bangor University, College of Health & Behavioural Sciences
Institute of Medical & Social Care Research, Y Wern, Normal Site, Holyhead Road, Bangor, Gwynedd LL57 2PZ
Telephone: 01248 388095
Email: nworth@bangor.ac.uk
http://www.bangor.ac.uk/imscar/nworth

RANDOMISATION PARAMETER ACTIVITY LOG (NWORTH USE ONLY)

Periodic review of database to be completed: NA (single use block randomisation)

Parameter Log

Iteration	Date	Cell	Total	Strat 1	Strat 2	Strat 3	Start 4	Simulations run?	Simulation file
INITIAL									

Randomisation check

Date	N	Total	Strat 1	Strat 2	Strat 3	Start 4	Acceptable	Adjust parameters?
Example	*30*	*15:15*	*14:16*	*16:14*	*NA*	*NA*	*Yes*	*NO*

North Wales Organisation for Randomised Trials in Health (NWORTH)
Bangor University, College of Health & Behavioural Sciences
Institute of Medical & Social Care Research, Y Wern, Normal Site, Holyhead Road, Bangor, Gwynedd [illegible]
Telephone: 01248 [illegible]
Email: nworth@bangor.ac.uk
http://www.bangor.ac.uk/imscar/nworth