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Pitts, Laura

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Utilising Applied Behaviour Analysis in Schools for Pupils with Special Educational Needs

Laura Pitts

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Yr wyf drwy hyn yn datgan mai canlyniad fy ymchwil fy hun yw’r thesis hwn, ac eithrio lle nodir yn wahanol. Caiff ffynonellau eraill eu cydnabod gan droednodiadau yn rhoi cyfeiriadau eglur. Nid yw sylwedd y gwaith hwn wedi cael ei dderbyn o’r blaen ar gyfer unrhyw radd, ac nid yw’n cael ei gyflwyno ar yr un pryd mewn ymgeisiaeth am unrhyw radd oni bai ei fod, fel y cytunwyd gan y Brifysgol, am gymwysterau deuol cymeradwy.

I hereby declare that this thesis is the results of my own investigations, except where otherwise stated. All other sources are acknowledged by bibliographic references. This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree unless, as agreed by the University, for approved dual awards.

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Appendices

Abstract

Applied behaviour analysis (ABA) uses scientific principles of learning and behaviour to understand and develop socially significant behaviour. Interventions based on ABA have been demonstrated to be effective in reducing barriers to learning and improving outcomes for individuals with Autism Spectrum Disorder (ASD). Research on integrating ABA within UK schools for pupils with ASD is necessitated. This thesis explores the development and implementation of a school-based ABA intervention model which has been delivered and evaluated on-site within a UK special needs school. In this model behaviour analysts worked in collaboration with school-based teaching teams, together they designed and implemented function-based behaviour support plans and individual education programmes, utilised ABA teaching strategies, and promoted the generalisation of skills. This thesis discusses how this school-based ABA intervention model was practically and effectively implemented.

Chapter 2 looks at effective components of ABA-based skills teaching used within the model, and reviews some of the currently available literature on these components, including individual strategies and components of discrete trial teaching including, instructions, prompting, error correction, reinforcement, data collection, and mastery criteria. Chapter 3 presents the first study in the UK to utilise a control group study to compare the ABA intervention model to education as usual for young children with ASD. Chapter 4 presents the first study in the UK to evaluate the effects of the model across the key stages to look at older children and adolescents, as well as young children. Chapter 5 looks more closely at the under-researched area of mastery criteria and presents a study which evaluates the effects of differing mastery criteria on the maintenance of skills in children with ASD. In chapter 6 all three studies are discussed in light of their findings,

implications for practice, limitations, recommendations for future work, and contributions to the field.

Chapter 1

~ Introduction ~

Applied behaviour analysis (ABA) refers to the practical application of the scientific principles of learning and behaviour; it is used to understand and develop socially important behaviour. Practitioners of ABA seek to increase behaviours which are functional and meaningful to an individual (Bear, Wolf, & Risley, 1969). ABA is a well-developed scientific discipline which focuses on the analysis, design, implementation, and evaluation of environmental variables. Behaviour analysts rely on observation, measurement, and the functional analysis of the relations between the environment and behaviour. By adjusting environmental events, including antecedent stimuli and consequences, behaviour analysts aim to produce practical and significant changes in meaningful behaviour, which in turn improve the quality of life of the individual (Behaviour Analyst Certification Board [BACB], 2019).

ABA interventions have been utilised across various populations and settings including brain injury, dementia management, substance abuse, occupational safety, and education. Some of the first applications of ABA were with individuals with intellectual disabilities and autism spectrum disorder (ASD) and there is a large evidence base supporting the efficacy of ABA interventions with this population. Applications of ABA with people with Intellectual disabilities and developmental disorders have been demonstrated to be effective across the lifetime: in children, adolescents, and adults (BACB, 2019; Ivy & Schreck, 2016).

Interventions based in ABA for young children with developmental disorders such as ASD, include intensive and comprehensive interventions which are designed to improve cognition, language, social skills, and self-help skills. Research spanning a number of decades has demonstrated that intensive applications of ABA are an effective approach for children with ASD (BACB, 2014, 2019; Matson, Benavidez, Compton, Paclawskyj, & Baglio, 1996). Applications of ABA with older individuals tend to focus on teaching behaviours necessary to function effectively at home, at school, and out in the community. ABA is also utilised to reduce behaviours which may be endangering health and safety, and limiting educational, residential, or vocational opportunities of clients (BACB, 2019; Ivy & Schreck, 2016).

Despite wide recognition and a substantial evidence base, applications of ABA for pupils with intellectual disabilities and ASD within schools in the UK are rare (ABA4ALL, 2019). However, the number of pupils with special educational needs (SENs) in England has increased for the third consecutive year, with 14.9% of pupils now defined as having a SEN. ASD is the most common primary diagnosis for pupils with an Education Health Care Plan (EHCP), with 29% of pupils with an EHCP having ASD as a primary diagnosis (Department for Education [DfE], 2019). Educational settings are obliged to provide SEN support in line with the Special Educational Needs and Disability (SEND) Code of Practice 0-25 (DfE, 2015). The code of practice states practitioners should have a good understanding of pupils' strengths and needs and should address them using evidence-based interventions. It states practitioners should consider a range of effective evidence-based teaching approaches, strategies, and interventions in order to support individual's needs. ABA-based interventions meet these stipulations; thus, it is perhaps surprising ABA hasn't been more widely adopted in educational settings in the UK. The lack of uptake could be due to a number of barriers, such as a shortage of trained professionals, common misconceptions, acceptance, and funding, as well as an existing gap between the research evidence and practice (Fielding et al., 2013; Johnson & Hastings, 2002). This thesis will discuss these barriers in more detail and attempt to address them by exploring a practical and affordable ABA intervention model which has been adopted and evaluated within a special needs school setting in the UK. It discusses the work which has been conducted via three studies which have aimed to:

1. Expand the evidence base for ABA intervention models which can be delivered within existing special needs school settings (study 1 & 2).
2. Describe an ABA intervention model in which multi-disciplinary teams collaborate to provide behaviour support and individualised education programmes (study 1 & 2).
3. Compare the application of this ABA intervention model to a control group who received education as usual (study 1).
4. Utilise the ABA intervention model to target a comprehensive range of behaviours and skill development across the key stages for older children and adolescents, as well as young children (study 2).
5. Evaluate the specifics of teaching within the model including strategies, such as instructions, prompting, error correction, reinforcement, data collection, and mastery criteria (chapter 2 & study 3).

This first chapter will introduce the aims outlined above in the context of some of the currently available literature. The subsequent chapters including chapters 3, 4, and 5 have been published or have been submitted for publication and as such are written up as independent studies for this purpose. Chapter 6 provides final discussion and closing conclusions in light of the outcomes of all three studies, their relative strengths and limitations, clinical implications, and implications for the field, as well as suggestions for future research.

ABA and Autism Spectrum Disorder

ASD is a neurodevelopmental disorder characterised by deficits in social interaction and social communication, and by restricted, repetitive, and inflexible behaviour. Deficits impact personal, family, social, educational, and occupational functioning (American Psychiatric Association, 2013; World Health Organisation, 2016). Around 1.6% of children in the UK are estimated to have ASD (Rydzewska et al, 2018; Taylor, Jick, & MacLaughline, 2013). It is reported 50%-70% of children with ASD also have additional intellectual disabilities (Chakrabarti & Fombonne, 2001; Yeargin-Allsopp, et al., 2003).

There are a variety of treatments and interventions available for ASD, however the empirical evidence base for treatments vary significantly. There are a number of biological treatments which include medications which can help alleviate some of the symptoms of ASD, for example, hyperactivity, attention deficit, depression, or seizures. There aren't any medications which cure ASD or treat all of the main symptoms (Centre for Disease Control and Prevention, 2019; Levy, 2003). Complementary and alternative treatments may be used in attempt to alleviate some of the symptoms of ASD, these treatments include special diets, gastrointestinal therapy, chelation therapy, intravenous immunoglobulins, and oxygen therapy. These types of treatments have no proven benefits and are highly controversial (Medavarapu, Marella, Sangem, & Kiaram, 2019; Levy, 2003). It is reported that over 30% of parents with children with ASD have tried complementary or alternative treatments and 9% are using potentially harmful treatments (Levy, 2003).

Non-biological treatments or interventions for ASD may include behavioural, developmental or communication based approaches. Speech and language therapy aims to develop language and communication skills through verbal communication or through gestures or pictures. Occupational therapy teaches independent living skills which might include fine and gross motor development, dressing and eating. Both speech and language therapy and occupational therapy incorporate many different interventions, techniques and tools for which the evidence base varies tremendously. However, both may help some individuals particularly when it's delivered as part of an individualised multi-component programme provided by a multi-disciplinary team (Research Autism, 2016a, 2016b).

Sensory integration therapy claims to help the individual deal with sensory information, like sights, sounds, and smells. However, there is limited empirical evidence of the effectiveness this treatment (Medavarapu et al., 2019). Auditory integration therapy requires the individual to listen to modulated music of varying volumes and pitches, this claims to modify central auditory processing which in turn improves language and behaviour. Empirical research doubts these claims and there are no confirmed benefits to this therapy (Medavarapu at al., 2019).

Other approaches or interventions include Developmental, Individual Differences, Relationship-Based Approach (DIR; also known as Floortime) which focuses on emotional and relational development, and the Treatment and Education of Autistic and related Communication-handicapped Children (TEACCH) which is a life-time approach which utilises visual cues to teach and support individuals. These approaches have shown some possible benefits in some cases, however the evidence based is limited and further research is required to investigate the efficacy (Medavarapu at al., 2019).

Interventions based on ABA have a significant evidence base and have demonstrated benefits for use with individuals with ASD (Medavarapu at al., 2019; Lindgren & Doobay, 2001). When compared to standard or education as usual (EAU), interventions based on ABA have been found to be more effective in increasing language and communication, cognitive skills, and adaptive behaviour in children with ASD and learning difficulties (LD)

(Eikeseth, Smith, Jahr, & Eldevik, 2007; Eikeseth et al., 2009; Eikeseth, Smith, Jahr, & Eldevik, 2002; Eldevik, Eikeseth, Jahr, & Smith, 2006; Grindle et al., 2012; Petters-Scheffer, Didden, Mulders, & Korzilius, 2010, 2013).

A significant portion of the existing evidence base evaluating ABA interventions with individuals with ASD and LD focuses on early intensive behavioural intervention (EIBI) applications of ABA. EIBI utilises function-based interventions, reinforcement strategies, prompt and prompt fading strategies, discrete trial teaching, and natural environment teaching (described in chapter 2 and 3) to effectively teach a comprehensive range of skills, including; language and communication skills, cognitive skills, and adaptive skills to children with ASD, other developmental disorders and LD's (Anderson, Avery, DiPietro, Edwards, & Christian, 1987; Eikeseth et al., 2002; Lovaas, 1987; McEachin, Smith, & Lovaas, 1993; Sheinkopf & Siegal, 1998; Smith, Eikeseth, Klevstrand, & Lovaas, 1997).

EIBI programmes are based on comprehensive skill assessments. Programmes are individually designed based on the outcomes of skill assessments and functional behaviour assessments. From these assessments, bespoke educational programmes and behaviour support plans are developed and implemented. EIBI begins at a young age; children are typically between the ages of 2- and 6- years old at the start of the intervention. Children generally receive 20 to 40 hours of direct teaching per week. ABA tutors or therapists and often parents are trained by a behaviour analyst to deliver the intervention (Granpeesheh, Tarbox, & Dixon, 2009).

Early EIBI Research

Lovaas (1987) conducted the first large scale study evaluating the effects of EIBI for young children under 4-years of age with ASD. The outcomes of children who participated in a comprehensive intervention programme in which they received an average of 40 hours per week of 1:1 teaching based on the principles of ABA, were compared to the outcomes of a control group of children who received treatment as usual. Outcomes revealed 47% of the children who received EIBI achieved normal intellectual and educational functioning and were able to attend general education classes, in contrast to only 2% of the children in the control group. Significant improvements were seen in another 40% of children who received EIBI, but they continued to require specialised intervention. Ten percent of children in the EIBI group demonstrated minimal improvements and continued to require intensive ABA intervention, in contrast to 53% of children in the control group who demonstrated minimal improvements and required further intervention. These outcomes suggested EIBI was effective in improving intelligence and educational attainment.

The early work from Lovaas came under criticism for research methodology including criticism around non-randomised assignment to group. Instead assignment was based on the availability of therapists, however this is common practice in clinical research is generally accepted by clinicians (Kazdin, 1992 as cited in Eikeseth, 2001). The participants in all groups were well matched on key variables including age at diagnosis, age at intervention, socio-economic status, number of siblings, gender, onset of walking, neurological damage, prorated mental age, recognisable words, absence of recognisable words, toy play, absence of toy play, absence of peer play, self-stimulation, abnormal speech, sensory deficit, adult rejection, tantrums, and absence of toilet training (Baer, 1993 as cited in Eikeseth, 2001).

Further criticisms of the work by Lovaas (1987) include participant selection bias, a lack of independent blind assessors, and a lack of procedural integrity measures (Bassett, Green, & Kazanjian, 2000). The study did not include children with severe or profound intellectual disabilities. Thus, the participants may not have been representative cross section of the population of children with ASD (Bassett et al., 2000).

Other criticisms of the early work by Lovaas have come from the intervention programme being costly and labour intensive; the programme required many highly trained therapists. The intrusiveness and aversiveness of the methods adopted have also been criticised (Birnbrauer & Leach, 1993). The aim of more modern ABA intervention is to increase adaptive behaviour and decrease maladaptive behaviour, through the use of reinforcement-based strategies where possible. More sophisticated assessment tools, such as functional analysis have been developed to ensure the implementation of more positive appropriate intervention. Least or less intrusive procedures are adopted now and researchers continue developing more effective and socially acceptable strategies for managing maladaptive behaviour (Matson et al., 1996).

Later EIBI Research

Later evaluations of EIBI including those of more contemporary applications report encouraging outcomes and have demonstrated consistently positive gains (Smith et al., 1997; Eldevik, Titlestad, Aarlie, & Tonnesen, 2019; Howard, Sparkman, Cohen, Green, & Stanislaw, 2005; Sallows & Graupner, 2005; Smith, Groen, & Wynn (2000). In more recent control trial studies, children who received EIBI treatment were found to outperform treatment as usual comparison groups on measures of adaptive behaviour, communication and language skills, daily communication skills, and socialisation. (Cohen et al., 2006; Eldevik et al., 2019; Howard et al., 2005; Petters-Scheffer et al., 2013).

A volume of meta-analytic review evidence support the findings of the studies presented, as well as many other studies which have reported on the effectiveness of EIBI for increasing language, intellectual functioning, and adaptive behaviour in children with ASD and LD. (Eldevik et al., 2009; Makrygianni & Reed, 2010; Makrygianni, Gena, Katoudi, & Galanis, 2018; Petters-Scheffer, Didden, Korzilius, & Sturmey, 2011; Virues-Ortega, 2010). A meta-analysis pools the results of multiple individual studies and statistically analyses them as a whole which results in more robust outcomes than standalone studies (Cooper, Hedge & Valentine, 2019). Meta-analyses tend to report effect sizes which quantify the size of the difference between two groups. The larger the effect size the stronger the relation between two variables is said to be (Rosenthal, 1994).

Eldevik et al. (2009) conducted a meta-analysis which included 34 evaluations of EIBI for children with ASD. Results revealed children who received EIBI made greater gains on measures of IQ than children in the no intervention control groups or children who received eclectic provision, this effect size was found to be large. Virues-Ortega (2010) conducted a meta-analysis which included 22 research studies evaluating EIBI and found that long-term, comprehensive ABA intervention had medium to large effects on intellectual functioning, language development, daily living skills, and social functioning. Makrygianni and Reed (2010) evaluated 14 EIBI studies and found EIBI is effective in improving intelligence, language, communication, and social skills with moderate to high effect sizes on adaptive behaviour. EIBI was also found to be more effective than eclectic, control group interventions in improving intelligence, language skills, and adaptive functioning.

In a further meta-analysis by Petters-Scheffer et al. (2011), 11 studies were evaluated. Outcomes revealed children who received EIBI outperformed children in the control groups on IQ, non-verbal IQ, expressive and receptive language, and adaptive behaviour. Makrygianni et al. (2018) conducted a more recent meta-analysis which was intended to provide a comprehensive and up-to-date assessment of behavioural intervention for children with ASD. Twenty-nine studies were evaluated across three domains: a) verbal and non-verbal IQ, b) receptive and expressive language, and c) adaptive behaviour. Outcomes revealed ABA intervention resulted in moderate to high effects in all three domains. ABA intervention was particularly effective in improving intellectual abilities, moderate to very effective in improving communication skills and expressive and receptive language skills, and moderately effective in improving non-verbal IQ, adaptive behaviour, and socialisation.

In a Cochrane systematic review of the evidence for EIBI for children under 6-years-old with ASD, Reichow, Hume, Barton, and Boyd (2018) reviewed the effectiveness of EIBI for increasing functional behaviours and skills, decreasing autism severity, and improving intelligence and communication skills. The review included RCTs, quasi-RCTs, and controlled clinical trials in which EIBI was compared to a no-treatment or TAU control condition. Evidence was found for EIBI improving adaptive behaviour, however no evidence was found for autism symptom improvements. Results indicated EIBI improves IQ and receptive and expressive language skills, but no evidence at post-treatment that EIBI improves problem behaviour. They conclude there is weak evidence that EIBI may be an effective intervention for some children with ASD. The authors did note the strength of the evidence is limited as it predominantly arises from small studies which are not of the optimum design. They also caution that due to the inclusion of non-randomised studies, there is a high risk of bias.

Much of the research reviewed thus far merits the use of EIBI for young children with ASD. However, there is some evidence, which suggests outcomes are much more varied. Some studies report low rates of effectiveness of EIBI for some children receiving intervention in UK home and community settings (Bibby, Eikeseth, Martin, Mudford, & Reeves, 2002; Howlin, Magiati, & Charman, 2009; Magiati, Charman, & Howlin, 2007). In a study by Bibby et al. (2002) data for 66 children with ASD who received parent-managed home-based and community-based EIBI in the UK were reviewed. Using a pre-post design, they found both mental age and adaptive behaviour improved significantly for only a subgroup of children. Significant changes in IQ were not observed.

Magiati, Charman, and Howlin (2007) compared outcomes for pre-school children with ASD receiving autism-specific nursery provision or home-based EIBI in a community setting. The study included 44 children between the ages of 23 and 53 months. Cognitive, language, play, adaptive behaviour skills, and severity of autism were assessed at intake and two years later. Results indicated both groups made improvements in age equivalent scores, but standard scores changed little over time. At follow-up, no significant group differences were found in cognitive ability, language, play or severity of autism. The only difference in favour of the EIBI group, was for daily living skills standard scores.

In a systematic review conducted by Howlin, Magiati, and Charman (2009) home-based EIBI for children with ASD was evaluated. Eleven studies involving children with ASD under the age of six were included in the review. The studies incorporated interventions which were delivered for a minimum of 12 hours per week and a duration of at least 12 months. The studies included adequate data on IQ or other standard measures. The results of the review demonstrated EIBI improved IQ outcomes compared to comparison groups. At an individual level there was significant variability in outcomes, with some indication that initial IQ (but not age) was associated with progress. Overall Howlin et al. (2009) concluded there was strong evidence for the effectiveness of EIBI for some, but not all young children with ASD. It has been reasoned that EIBI is difficult to replicate in home and community settings as it is very intensive and comprehensive, requires highly skilled staff including Board Certified Behaviour Analyst's, and a high level of parental involvement and commitment (Eikeseth, 2011; Lovaas, 2003 as cited in Eikeseth at al., 2012). These factors or a combination of these factors may give rise to the low rates of effectiveness found in some studies, however further research is required to confirm or rebut this (Eikeseth at al., 2012).

In addition to the counter evidence the strength of the evidence based for EIBI is somewhat limited due to methodological flaws and problems in reporting. Research Autism (2017) identified a number of limitations in the evidence base including the fact some studies have used small sample sizes and some have employed single-case design methodologies (such as multiple baseline or pre-post-test). Whilst it is recognised that single-case design studies can be limited in terms of generalisability, they can have substantial methodological advantages of over other designs (Nock, Michel, & Photos, 2007), the relative advantages of which are discussed later. Some studies have also been limited as they have been retrospective case studies, some employed comparative designs, but did not ensure participants were evenly matched between intervention and comparison groups, and controlled studies where participants were evenly matched were non-randomised. Some also failed to use independent assessors at pre-and post-test who were blind to the conditions of the study. More methodologically rigorous comparative studies of EIBI vs. other autism specific pre-school programmes are required. Further work is also required to focus on fidelity of the intervention and the moderators and mediators of intervention effectiveness (Research Autism, 2017).

Studies have also come under criticism for failing to describe all critical aspects of intervention. Due to the complexity and intensity of EIBI reporting all critical aspects of the independent variable can be difficult (Lechago & Carr, 2008). Future research needs to try and overcome these limitations. Lechago and Carr (2008) have made some recommendations for reporting specific features of interventions, including details of programme personnel, teaching format, instructional procedures, skill maintenance, generalisation, data collection, mastery criteria, duration, intensity, and behaviour management. Following these recommendations the research presented in this thesis aimed where possible to report all of the specific features of intervention listed above. Outlining these details is critical in allowing for sufficient replication, which is vital in determining the validity and reliability of outcomes, as well as checking for generalisation to other participants and settings. Procedural integrity: the extent to which an intervention has been implemented as designed is also important, it permits for clear interpretation of the outcomes and is therefore essential in the empirical evaluation of intervention testing, as well as in the dissemination of evidence based practice (Perepletchikova, 2011). Thus the work in this thesis aimed to design and utilise procedural integrity measures and checks. For published work and work submitted for publication there are limitations with regards to article length, as such as much detail as possible on the critical aspects of the intervention have been included whilst respecting the relevant journals word limits and formats.

EIBI and Intensity

A large volume of the EIBI studies have evaluated the effects of programmes which have delivered 20-40 hours per week of direct teaching. The BACB (2014) suggests focused or low intensity ABA intervention typically ranges from 10-25 hours of direct teaching per week. Specific programmes for severe destructive behaviour may necessitate additional hours per week (e.g. day treatment or inpatient treatment for severe self-injury). Comprehensive ABA treatment or high intensity intervention may provide 30-40 hours of direct teaching per week. Whilst the majority of hours are conducted on a 1:1 direct teaching basis, teaching in a small group can gradually be incorporated as children’s skills develop. Very young children may begin with a lower number of hours per day with the aim of increasing the hours as their capacity to participate increases.

Pellecchia, Iadarola, and Stahmer (2019) suggest recommendations for a minimum number of hours fail to consider family circumstances; for example, whether the family is physically able to provide and sustain over time high intensity treatment hours. What is practically and financially feasible may vary based on parental income, job requirements, family support, and number of children in the family. Obligating families to commit to a minimum number of hours may result in additional burden and tension for parents who may already be under substantial stress, which can in turn jeopardise outcomes. High treatment hours may leave little time for leisure and family activities.

When the delivery of intensive intervention with a high number of 1:1 direct teaching isn't possible, lower intensity intervention with lower number of 1:1 direct teaching hours may be delivered. When looking more specifically at low intensity versus high intensity behavioural intervention, research suggests high intensity typically results in better outcomes for young children with ASD (Eldevik et al., 2019; Linstead et al., 2017a; Reichow and Wolery, 2009). Eldevik et al. (2019) found 18.1 hours of 1:1 direct teaching resulted in higher outcomes in intellectual functioning, adaptive behaviour, and autism severity than 11.1 hours of direct teaching. Reichow and Wolery (2009) analysed effect sizes for IQ improvements reported in university-based studies which compared high and low intensity interventions. The studies included children with ASD who were under 7-years of age at intake. They concluded the highest number of direct teaching hours resulted in the greatest IQ improvements. Definitions of high and low intensity interventions differ across the literature in terms how many hours of 1:1 direct teaching are provided. High and low intensity is sometimes used to simply differentiate between interventions delivering a different number of hours of 1:1 teaching within specific studies, for example Eldevik et al. (2019) 18 hours vs. 11 hours, however the authors note that 18 hours may be considered low intensity in the wider context.

Linstead et al. (2017a) investigated the relationship between intensity and mastery of learning objectives with 726 children aged between 1- and 12-years of age. All children had a diagnosis of ASD and received community-based behavioural intervention services. Outcomes revealed a strong relationship between intensity and mastery of learning objectives, with higher intensity interventions predicting greater progress. In a further study by Linstead et al. (2017b) the effects of intensity and duration on eight different domains, including academic, adaptive, cognitive, executive function, language, motor, play, and social were evaluated. Data were analysed from 1468 children with ASD aged between 18-months to 12-years-old, who received individualised ABA intervention. Results identified both intensity and duration as significant predictors of mastered learning objectives for all eight domains. The strongest response was revealed for academic and language domains, with effect sizes of 1.68 and 1.85 for treatment intensity and 4.70 and 9.02 for treatment duration. These results are in line with previous research which has suggested intensity and duration of intervention positively effects outcomes.

Reed et al. (2007) evaluated the effects of low and high intensity home-based behavioural intervention. Participants included 27 children with ASD between the ages of 2- and 4-years-old. One group of children received low intensity intervention delivered for an average of 12 hours per week and a second group received high intensity intervention delivered for 30 hours per week. Following nine to ten months of intervention the higher intensity group made greater gains in both intellectual and educational functioning. Within the high intensity group however, the highest intensity was not associated with the highest outcomes. Findings suggested 40 hours per week may not be optimal and diminishing returns may be observed once over a certain number of hours, possibly around 20 hours per week. When looking at other studies and the relations between hours of intervention and child outcomes, these findings are supported. Other studies (e.g. Sheinkopf and Siegel, 1998; Smith et al., 2000 as cited in Reed et al., 2007) report greater effect sizes than those reported in the Lovaas (1987) study, despite intervention of less than 40 hours per week.

Virues-Ortega (2010) also evaluated intervention intensity and duration of EIBI on outcomes for children with ASD. Outcomes revealed language skills improved more from higher intervention duration and functional and adaptive behaviour profited from higher intervention intensity. A meta-analysis was replicated for total duration of intervention. Outcomes revealed dose–response effects for language, and functional and adaptive behaviours. However, dose–response analysis for intellectual functioning to some degree demonstrated a point of diminishing returns. However, these outcomes indicate this could be different for intellectual functioning, verbal skills, and functional and adaptive behaviour. Thus, further research to explore these differences is required.

Whilst further research is required into intensity of intervention and points of diminishing returns, children are still making significant progress through low intensity intervention. Eldevik, Hastings, Jahr, and Hughes (2012) compared outcomes of low intensity behavioural intervention to TAU with children with ASD aged between 2- and 6-years-old. Thirty-one children received what the authors defined as low intensity behavioural intervention for an average of 13.5 hours per week in mainstream pre-school settings. Twelve children received TAU. After two years children who received behavioural intervention demonstrated higher IQ scores and adaptive behaviour scores than those who received the TAU. The authors note the intervention hours would be considered low intensity. However, these group level outcomes were comparable to studies providing more intensive intervention. Considering the somewhat low intensity of intervention, the outcomes appear promising especially in terms of meaningful improvements in IQ scores for individual children.

In a more recent study Eldevik et al. (2019) evaluated the effects of community-based EIBI outcomes for children with ASD. Seventy-four children between 2- and 7- years-old at intake were distributed across three groups based on referrals. One group of children received low intensity intervention which consisted of 11.1 hours of direct teaching per week, a second group of children received high intensity intervention which consisted of 18.1 hours of direct teaching per week, and a third group received TAU. TAU was based on a mix of eclectic special education interventions tailored to meet the needs of the child. Following one year of intervention both the low intensity and high intensity groups made greater gains than the TAU group. The high intensity group outperformed the low intensity group on measures of adaptive behaviour, suggesting increased hours of 1:1 direct teaching leads to greater outcomes. However, the low intensity group still demonstrated significantly larger gains in IQ than the TAU group, suggesting low intensity intervention was still superior to TAU.

In sum, children are making significantly greater gains through low intensity ABA interventions when compared to children receiving TAU (Eldevik et al., 2012, 2019).

ABA within School-based Settings

Much of the EIBI research has focused on the delivery of the intervention by trained tutors or therapists with support from parents in the child's home or within a university or centre. School-based applications are relatively under-researched in comparison (Grindle et al., 2012). However, school-based applications could make ABA more accessible to more children. Pupils' barriers to learning can be addressed through ABA intervention in the classroom. ABA interventions would help schools fulfill their obligations to provide SEN support in line with the SEND code of practice (DfE, 2015). In addition, ABA intervention removes the barriers or problems commonly associated with parent led home or centre-based interventions, such as practical, familial, and financial constraints (Pellecchia et al., 2019). The limited research on school-based applications of ABA along with a number of other factors may explain why ABA interventions in UK schools are rare. The rarity could be due to a number of barriers such as limitations with intensity, dissemination, training, common misconceptions, funding, acceptance, and a gap between the research evidence and practice (Horner, Blitz, & Ross, 2014; Fielding et al., 2013; Roll-Petterson, Olsson, & Rosales, 2017).

Current EIBI practice of ABA can be limited due to their intensity and they do not always sit well within existing school settings. EIBI can be costly, time and resource intensive, and require high response effort from those involved. Thus, school-based delivery might need to look different to the current EIBI practice. School-based practice needs to be more flexible, adaptable, and affordable. They might also need to be less intensive, consider funding restrictions, school timetables, hours, school holidays, and require less parental involvement. School-based models which take into account these factors require development and evaluation.

The shortage of ABA trained professionals, as well as a shortage ABA related training, knowledge and common misconceptions amongst health and educational professionals undoubtedly impacts the uptake of ABA across settings (Fielding et al., 2013; Johnson & Hastings, 2002). Some professionals have many common misconceptions of ABA often centered around reinforcement, teaching procedures, staffing ratios, generalisation, and how early work in the field was initially implemented and developed. These misconceptions often add to professionals and funders reluctance to invest (Fielding et al., 2013). Thus, the challenge for behaviour analysts is to disseminate sensitively and work diligently to demonstrate efficiency.

Funding issues are undoubtedly a barrier to implementation, with many funders reluctant to grant funding possibly due to the cost of providing individualised programmes and hiring staff. The high levels of 1:1 teaching described in EIBI applications of ABA means it can be labour intensive and expensive (Petters-Scheffer et al., 2012). Back in 2007, Chasson, Harris, & Neely reported the delivery EIBI for 35 hours per week came at an average cost of £31,000. After a number of years, this cost is likely to be higher and this can further add to funders and stakeholders reluctance to invest. There is currently little research which looks specifically at training school staff to deliver interventions, much of the research is focused on hiring trained ABA tutors or therapists, and in some cases training parents. Thus, more research is required into cost-effective school-based models in which ABA training can be provided to teachers and teaching assistants who can deliver interventions with pupils daily, reducing the cost of hiring ABA trained staff for programme delivery. Research is also required into models in which less 1:1 teaching is provided and more group teaching is provided.

There is also currently limited real-world research evaluating applications of ABA which are designed and implemented on-site in schools which take into account school-based practicalities, local context, and the culture of the school. Central to the successful adoption of evidence-based interventions is local context. The intervention itself and the local context in which the intervention sits affects both the quality of the implementation and whether the intervention results in effective outcomes. Contextual fit is based on exactly this principle; the balance between strategies and components of the intervention and the values, needs, skills, and resources of those who implement it (Horner et al. 2014). Thus, all these variables require careful consideration when planning and implementing interventions within school-based settings. Developing interventions which consider contextual fit and providing on-site training with staff may lead to increased acceptance and commitment (Horner et al. 2014).

Although evaluations of applications of ABA interventions within existing school settings are limited at present, the few evaluations which have been conducted demonstrate some encouraging outcomes (Eldevik et al., 2006; Foran et al., 2015; Grindle et al., 2012; Lambert-Lee et al., 2015; Peters-Scheffer et al., 2013). Within an autism-specific class in a mainstream school in the UK, Grindle et al. (2012) evaluated ABA interventions for 11 pupils between 3- and 7-years of age. Children attended school for 30 hours per week during school terms. Across the course of the school day 1:1 teaching sessions were alternated with small-group activities. The children also accessed mainstream classes whilst supported by an ABA therapist who shadowed the child and provided prompts and reinforcement when required (e.g. for correctly following instructions, interacting with peers, and participating in activities). Children demonstrated gains with large to moderate effect sizes on standardised measures of IQ and adaptive behaviour following one year of ABA intervention, with further increases seen following two years of intervention. Standardised test outcomes for nine children were compared to a group of children who received EAU. Controlled comparison results demonstrated statistically significant gains in adaptive skills for those children who participated in ABA intervention.

Eldevik et al. (2006) retrospectively compared a group of pre-school children under

6-years-old with ASD who received 10-20 hours of ABA intervention, to those who received eclectic intervention within school-based settings in Norway. Children who received ABA intervention made greater gains on measures of language, intelligence and adaptive behaviour than those who received eclectic intervention. In the Netherlands, Peters-Scheffer et al. (2010) compared ABA intervention to regular education with children with ASD between the ages of 3- and 6-years-old. Children in the ABA intervention group who received an average of 6.5 hours of 1:1 teaching per week were compared to a control group who received regular intervention. After eight months of intervention, children in the ABA intervention group demonstrated significantly higher developmental ages and higher gains in adaptive skills than children in the control group.

Foran et al. (2015) evaluated ABA interventions implemented within a UK special needs school setting. Seven children with ASD all under 7-years of age participated. Within this intervention model children were supported in class by trained teachers and teaching assistants. Trained staff implemented function-based behaviour support plans and individual education programmes and delivered an average of seven hours of 1:1 teaching per week. Following three academic terms of ABA intervention children demonstrated significant gains in IQ, along with significant gains in language, academic skills, and social and play skills. In addition, reductions in children's challenging behaviour were observed following function-based behavioural intervention. These preliminary results are very encouraging, but additional evaluations are necessary. Further evaluations across cohorts, schools, and the employment of a control group are also required.

Looking specifically at the few school-based applications of ABA which have provided low intensity interventions with low levels of direct teaching hours within school settings, the indication is children still make gains on measures of intelligence, language, and adaptive behaviour (Peters-Scheffer et al., 2010, 2013). However, school-based applications may need to be viewed differently to EIBI applications, especially in terms of intensity. With EIBI all teaching is delivered on a 1:1 basis, thus a child who receives 10 hours of 1:1 teaching per week, receives just 10 hours of ABA-based teaching per week. In the emerging school-based models such as that described by Foran et al. (2015) children receive more ABA-based teaching than this. Although the number of 1:1 direct teaching hours are low, support based on the principles of ABA is provided throughout the day, and the children are taught using a combination of both 1:1 teaching and group instruction. Trained class-based staff support pupils throughout the day, creating additional practice opportunities outside of 1:1 teaching times, and increased opportunities for the generalisation of skills. Individualised behaviour support helps reduce harmful behaviour and increase functional communication and skills. This is different to EIBI and is essentially an alternative application of ABA for children with ASD which warrants further evaluation.

ABA with older children and adolescents

To date, much of the work evaluating the effectiveness of school-based ABA interventions has been conducted with young children up to 7-years of age (Eldevik et al., 2006; Foran et al., 2015; Grindle et al., 2012; Peters-Scheffer et al., 2010, 2013). There is very little research into the effectiveness of EIBI and school-based ABA interventions for children and young people older than 7-years of age. This may in part be due to recommendations around early intervention and children beginning intervention as early as possible. From a biological or physiological perspective early intervention is key. Theories related to neuroplasticity and brain development suggests there are critical periods during which the brain develops and refines (Losardo, McCullough, & Lakey, 2016). Between 2- and

5-years of age the brain is forming quickly meaning it is malleable and more able to reorganise experiences than when the child is older. This plasticity means interventions have a better chance of being effective when they are delivered early (Losardo et al., 2016). When looking at age and intervention from a behavioural or learning theory perspective, early intervention is also key. Younger children have shorter learning histories and reinforcement histories for engagement in maladaptive behaviours. Teaching new skills and replacement behaviours to young children will likely increase positive behavioural repertoires and learning histories from the outset (Healy & Lydon, 2013).

Some evaluations of age at intake and the outcomes of EIBI for children with ASD have been conducted. Fenske, Zalenski, Krantz, and McClannahan (1985) compared the outcomes of nine children with ASD who began EIBI programmes prior to 5-years of age to another nine children with ASD who began the same programmes after 5-years of age. Children received EIBI via a private day school and treatment programme, which they attended for five and a half hours a day, five days per week for 11 months of the year. Parental support and training was also delivered in the child's home once per month. Results revealed age at intake was found to be related to public school placement and residence in parental home. This study used educational placement and parental home residence as a primary outcomes measure, while this ultimate outcome is important, other measures may also be useful here, such as measures of intelligence and adaptive behaviour, as well as other functional skills.

In a further study, Harris and Handleman (2000) compared the outcomes of 27 children who began EIBI between 2- and 5-years of age. Children received EIBI at a university-based educational instruction centre. Between 35 and 45 hours of teaching was delivered each week. Results indicated higher IQ at intake and younger age at intake was related to placement in a regular education class after discharge. Conversely lower IQ and older age were closely related to placement in special education classrooms. However, the authors do note the older children with lower IQ demonstrated measurable gains in IQ following intervention. They conclude that whilst children under 4-years of age at intake performed the best, the data should not be interpreted to suggest older children do not benefit EIBI.

The correlations between age at intake and better child outcomes is further supported in a meta-analysis by Makrygianni and Reed (2010). The majority of the studies evaluating the effects of age at intake only include young children, the effects for older children is limited. In one study by Lambert-Lee et al. (2015), older children and adolescents were included in an evaluation of a comprehensive ABA-based model employed in an autism-specific school within the UK. Data from a 12-month period for 53 pupils with ASD between 6- and 18-years-old were analysed. All pupils had individual education plans and function based behaviour support plans and received a combination of 1:1 teaching and group teaching based on the principles of ABA. Pupils were supported and taught throughout the school day by trained ABA tutors. The ABA tutors were degree level educated and all interventions were designed and supervised by an ABA supervisor and an ABA consultant. Outcomes revealed pupils of all ages made significant gains in language and learning skills, and adaptive behaviour.

Roth, Gillis, and DiGennaro Reed (2014) conducted a meta-analysis of published single-case research evaluating the effectiveness of behavioural interventions for older children and adults with ASD. The analysis included 43 articles with participants aged between 12- and 45-years of age. Outcomes revealed medium to strong effect sizes in the areas of academic skills, adaptive skills, problem behaviours, phobic avoidance, social skills, and vocational skills. The authors conclude the evidence for the use of behavioural interventions for older children and adults is promising. When looking specifically at the studies for older children and adolescences between 12- and 13-years of age, ABA has been demonstrated to be effective in teaching individuals a range of skills including: literacy skills (Delano, 2007), self-help skills including eating (Bledsoe, Smith, & Simpson, 2003), brushing teeth, and bag packing (Rayner, 2010), social skills including greetings and early conversational skills (Nientimp & Cole, 1992; Krantz & McClannahan, 1993), and reducing problem behaviour (Graetz, Mastropieri, & Scruggs, 2009).

With the exception of the presented study by Lambert-Lee et al. (2015), research evaluating ABA interventions for older children and adolescents tends to be significantly narrower in scope than that conducted with younger children. The focus with younger children has been to address a comprehensive range of behaviour or skill deficits, whereas the focus of ABA interventions for older children and young people has been to address more specific deficits or behaviours, typically a specific skill or small range of skills (Granpeesheh, Tarbox, & Dixon, 2009). Single-case design research dominates the evidence for ABA-based interventions for older children and adolescence. However, single-case designs are somewhat limited as results cannot be easily generalised to wider populations. On the other hand, single-case research designs have significant methodological advantages over large-sample group research designs. Single-case designs can demonstrate more well-defined causal relations between interventions and behaviour with greater efficiency than designs which include larger group samples (Horner et al., 2005; Nock et al., 2007). In comparison to single-case design, large-sample studies or group design studies are typically more costly, more time intensive, and require higher levels of staffing. (Nock et al., 2007). Assessment methods used in single-case designs allow for the evaluation of individual behaviour change patterns in the data, whereas group designs typically only employ pre- and post- intervention assessment. Single-case designs also permit multiple experimental phases, meaning practitioners can make detailed evaluations of patterns in data and the relations between manipulations and their effects over time (Horner et al., 2005; Nock et al., 2007). While single-case designs have various strengths and can be methodologically rigorous, generalisation issues remain. To increase the generalisation of ABA-based interventions with older children some larger group designs are also required.

Studies into the effect of intensity of behavioural interventions with older children are also required. Much of the evidence base to date has looked at the effect of low intensity behavioural intervention with young children under 7-years of age. In a rare study which also included older children, Granpeesh, Dixon, Tarbox, Kaplan, and Wilke (2009) investigated the effects of 1:1 direct teaching hours and age on the rate of learning. Participants included 245 children between 16 months and 12-years of age. Children received an average of 19 hours (range 5-42 hours) of 1:1 teaching per week. Results indicated younger children demonstrated an increased benefit from higher levels of 1:1 direct teaching hours when compared to older children. For young children between 2- and 7-years of age a significant increase in skill acquisition was associated with increased 1:1 direct teaching hours. For older children between 7- and 12-years a significant relationship between skill acquisition and the number direct 1:1 teaching hours was not demonstrated. Older children were observed to comparatively reach a ceiling, mastering around 17 behavioural objectives per month regardless of the number of 1:1 teaching hours received. The results of this study suggest a point of diminishing returns for older children and that lower levels of 1:1 teaching hours could be just as effective as a higher number with older children. However, the authors did not specify the minimum and maximum number of 1:1

teaching hours for the group of older children, nor did they draw any further conclusions with regards to 1:1 teaching hours. The authors also did not provide any possible explanations for older children displaying a point of diminishing returns. Possible explanations could lie in physiological factors related to brain development and neuroplasticity, it could also be related to the length of learning histories (Losardo et al., 2016; Healy & Lydon, 2013), or perhaps older children burn out from intervention sooner. There are a host of possible factors which require further investigation.

The school-based ABA intervention model

This thesis explores the application of a school-based ABA intervention model in which school-based staff and behaviour analysts collaborated to deliver ABA-based teaching and behaviour support. Pupils with ASD were supported by trained teachers and teaching assistants throughout the day using the principles of ABA. Trained staff delivered function-based behaviour support and individual education programmes, as well as five hours per week of direct 1:1 teaching to each pupil. Staff also targeted the generalisation of skills learnt within 1:1 teaching sessions within the classroom and around school. This school-based application of ABA forms the basis of the first two studies presented in this thesis. The aim was to explore and evaluate the application of ABA within the context of a UK special needs school. Of those few studies which have been conducted within UK schools to date (Grindle et al., 2012; Foran et al., 2015) none have included a control group which has run concurrently in the same educational setting as ABA-based interventions. Mindful of this gap in the literature the first study in this thesis investigated the effects of school-based ABA intervention in comparison to a control group who received EAU in a UK special needs school.

In addition, further evaluations of ABA interventions and factors affecting outcomes for older children are required. To date studies with older children and adolescents typically have small sample sizes or utilise single-case experimental designs, whereas research with younger children has utilised more group designs; replicating the effects of an intervention across multiple children within a group (Granpeesheh, Tarbox, & Dixon, 2009). With this in mind the second study in this collection utilised a group design to look at the effects of the school-based ABA intervention model with older children and young people (aged 8- to 13-years of age), as well as a younger children (aged 4- to 7-years of age). Like the first study it also aimed to add to the currently limited research base into the effectiveness of ABA interventions implemented within an existing UK special needs school setting, whilst evaluating the effectiveness of a model in which trained school staff support pupils using the principles of ABA, implement function-based behaviour support plans, utilise ABA teaching strategies, and foster the generalisation of skills.

All three studies presented in this thesis were completed in accordance with Bangor University guidance on ethics and governance. The control group study in chapter 3 was approved by the School of Psychology Ethics Committee (Ref: 2012-7102-A14082), the age comparison study in Chapter 4 was approved by the College of Business, Social Sciences, Education and Law Ethics Committee (see appendix A), and the study on mastery criteria in Chapter 5 was approved by the School of Education and Human Sciences Ethics Committee (Ref: 18-31, see appendix B).

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Chapter 2

~ Analysing effective components of skills teaching based on applied behaviour analysis ~

As the evidence base grows for ABA intervention models which provide fewer hours of 1:1 teaching, it is necessary to ensure teaching is as proficient as possible. The evaluation of individual strategies and components of DTT such as instructions, prompting, error correction, reinforcement, data collection, and mastery criteria becomes crucial in ensuring the most efficient strategies are utilised. When fewer hours of DTT are provided, it becomes even more essential to ensure the hours of DTT are of high quality. As the school-based intervention model described in this thesis was being developed some of the available literature on each of these areas was reviewed and some recommendations taken from this. Some of the reviewed literature is subsequently presented and discussed.

DTT is based on the idea that learning occurs as a result of a three-term contingency. Skinner (1969) detailed this three-term contingency, in which a consequence (either a reinforcer or punisher) is contingent upon a behaviour which is elicited following the presentation of a particular antecedent stimulus called a discriminative stimulus. Based on this contingency a discrete trial is a small unit of instruction, comprising of the presentation of stimulus and establishing operation, a prompt, a response from the pupil and a consequence (Smith, 2001). Each trial has a very distinct beginning (teacher delivered instruction or cue), middle (pupil response), and end (teacher delivered consequence). The consequence could be reinforcement or error correction dependent upon the pupil's response. Reinforcement increases the probability of the response occurring again in future in the presence of the antecedent (Skinner, 1969).

All of the individual discrete trial components are important, and practitioners should ensure the most effective component strategies are employed. Employing effective component strategies, such as instructions, error correction, and reinforcement are instrumental in maximising learning. Practitioners should also employ the most effective data collection procedures and mastery criteria.

Instructions

The beginning of a discrete trial consists of a antecedent stimulus which is known as a discriminative stimulus. The discriminative stimulus is anything in the environment which evokes a response. This can be a non-vocal stimulus or vocal stimulus such as an instruction. During DTT some practitioners recommend using the simplest language or limiting the instruction to one word (e.g. “cup”, rather than “find the cup”, or “point to the cup”). Limiting the instruction to just one word makes discrimination easier for the learner (Green, 2001). Leaf and McEachin (1999) recommend delivering simple instructions only at the beginning stages of learning and as progress is made, instructions should be extended and the language made more natural and increasingly more complex. Adopting more complex language reflects more natural situations and may aid generalisation. Leaf, Cihon, Leaf, McEachin, and Taubman (2016) suggest varying instructions from trial to trial. They suggest practitioners should consider how a pupil is responding to more complex instructions and determine whether acquisition is decelerated by the delivery of more complex instructions. If deceleration isn’t observed, then the pupil is likely to be ready for variation in instructions.

If generalisation is being programmed for, then varying the instruction in the initial stages of teaching may result in decelerated acquisition initially. However, this may lead to positive effects in terms of generalisation and maintenance longer term. Varied instructions can function as multiple exemplars which are likely to promote generalisation (Stokes & Baer, 1977). Nevertheless, it's important to remain mindful that these are practitioner recommendations, and whilst these recommendations appear to make sense in theory it would be beneficial to empirically evaluate the practical application of instruction delivery and variation. Practitioners typically draw on strategies and procedures which have already been demonstrated to be effective, thus having an empirically validated evidence base for instruction delivery and variation is essential. The evidence base would allow for the selection and implementation of the most effective strategies. Whilst there are likely to be some individual differences in the way individuals respond to strategies and procedures, it would still be beneficial to have some initial evidence from which to draw from. This way less 1:1 teaching time would be lost to testing possible strategies, instead teaching time could be maximised with potentially highly effective strategies being implemented from the outset.

Prompting

Prompting involves the presentation of a supplemental stimulus which is presented directly after the antecedent stimulus or along with the antecedent stimulus. The research base suggests many different prompting and error correction strategies are effective; and the effectiveness of strategies varies across different individuals, as well as the nature of the skill being taught (Carroll, Joachim, St. Peter, & Robinson, 2015; Smith et al., 2006; Turan, Moroz, & Croteau, 2012; Worsdell et al., 2005). In a recent evaluation Foran et al. (2018) compared three different prompting procedures when teaching receptive identification, labelling, and matching tasks to three children with ASD and related intellectual disabilities. Simultaneous prompting was compared with responsive time delay prompting and no-no prompting. Results demonstrated all three strategies were effective in teaching skills, no single prompting strategy was superior to another.

In the absence of a demonstration of one prompting procedure being consistently more effective than another, choices regarding which prompting strategy to adopt should take into account the setting in which the procedure will be employed. The complexity of the procedure, and if it can be employed by staff in the setting with accuracy should be considered. In school-based settings where trained teachers and teaching assistants work in classrooms with different pupils across the course of the day it may not be feasible to have staff trained in a multitude of different individual prompting strategies (Foran et al., 2018). Whilst it would be more cost and time effective to employ one prompting strategy for all pupils within a class, it would be important to determine if this strategy is effective for all pupils. Thus, future research should focus on the evaluation of this, and on the development of assessments which could be used to determine not only the most cost and time effective strategies, but those which are most easily and accurately employed by staff, as well as those which are the most effective and least intrusive for pupils.

Error correction

It is inevitable that during DTT pupils will make errors at which point it is important to provide correction to assist the pupil in learning the correct response. Identifying the most effective error correction strategies is essential in delivering effective and efficient teaching which maximises learning. A variety of error correction strategies have been used during DTT, much of the literature suggests a range of different error correction strategies are effective and efficacy varies from individual to individual (Carroll et al., 2015; Kodak et al., 2016; Rodgers & Iwata, 1991; Smith, Mruzek, Wheat, & Hughes, 2006; Worsdell et al., 2005). Therefore, initial assessments designed to identify the most effectual error correction strategies for each individual should be utilised.

McGhan and Lerman (2013) implemented a rapid error correction assessment to identify the most effective and least intrusive error correction strategies with five children with ASD. An initial assessment was conducted to compare four error correction strategies: (1) a vocal feedback error statement; (2) a model of the correct prompt by the teacher, but no requirement for the pupil to respond; (3) an active pupil response where the correct response was modelled by the teacher and the pupil was required to repeat the correct response; and (4) directed rehearsal where the teacher modelled the correct response and then represented the trial until the pupil engaged in three correct independent responses. Efficiency was assessed by measuring the total number of trials required for pupils to achieve mastery criteria. Following the initial assessment, validation assessments were conducted during which the most efficient error correction strategies were compared to less efficient ones. For four of the five pupil's initial assessment outcomes corresponded to the validation assessment outcomes. Suggesting initial assessments are useful in determining the most effective and least intrusive error correction strategies for some individuals.

Reinforcement

Reinforcement increases or strengthens a response and as such increases the probability of the response reoccurring in future (Skinner, 1969). It is an essential component of DTT, thus efficiency in terms of type of reinforcement and its delivery is critical in providing the best conditions in which pupils can acquire new skills. During DTT immediate brief access to a preferred item or activity is commonly delivered following correct responding, alternatively a token is delivered which can be exchanged for extended time with a preferred activity or a large amount of preferred items. Delivering tokens and a larger reinforcer at the end of the teaching session can be particularly useful as teaching momentum is less likely to be disrupted and more learning opportunities can be presented to the pupil. In addition, it has been suggested pupils may demonstrate a preference for receiving larger amounts of reinforcement at the end of a teaching session rather than small amounts throughout a teaching session (DeLeon et al., 2014).

Joachim and Carroll (2018) compared four types of consequences for correct responding on skill acquisition targets during DTT. Four children with ASD received DDT sessions during which correct responses resulted in praise, tangible items, tokens, or no differential consequence. Results revealed skills were acquired in the fewest number of sessions for three of the four participants when correct responding was contingent upon immediate delivery of tangible items, or tokens which could be exchanged for tangible items at the conclusion of the teaching session. Preferences for the different consequences were evaluated using a concurrent-chains assessment (Hanley, Piazza, Fisher, Contrucci, & Maglieri as cited in Joachim & Carroll, 2018). Results from this assessment indicated a preference for conditions delivering immediate or delayed tangible items for three of the four participants. Thus, it is suggested tangible items delivered either immediately or on a delayed basis should be utilised as consequences for correct responding in DTT.

Further research into response-reinforcer arrangements is required to more successfully identify the variables influencing preference and skill acquisition. It has been suggested variables such as reinforcer characteristics, response characteristics, and pupil characteristics could all influence preference and acquisition. Reinforcer characteristics include type of reinforcer (item, activity, social), reinforcer delivery, continuity of access, and conditioned reinforcers (i.e. tokens). Response characteristics may involve acquisition versus maintenance, or mastered tasks, and response effort (i.e. easy versus difficult tasks, small versus large tasks, high versus low preference tasks). Pupil characteristics such as chronological age, development level, cognitive functioning, and the presence of challenging behaviour which may be interfering with learning should also be assessed and considered. Identifying and understanding these influencing variables may lead to more effective assessments and teaching strategies being implemented for individual pupils (Ward-Horner, Cengher, Ross, & Fienup, 2017).

Data collection

Data collection is one vital component of ABA based teaching strategies such as DTT. Data are often collected on individual targets so practitioners can make data-based decisions regarding when targets are mastered or should be adjusted or expanded, or when teaching strategies should be adjusted, reduced or terminated. Thus, it is vital data collection procedures accurately reflect the progress of the target. Frequency of data is also vital in ensuring a clear picture of progress. Daily data collections are often used and are recommended (Leaf & McEachin, 1999).

One method of data collection frequently used is continuous data recording, also known as trial-by-trial data. This method typically involves recording pupils responses following each teaching trial, potentially providing the most complete record of pupil performance. However, continuous recording can be time consuming, and may affect teaching by decreasing momentum and rapport building between teacher and pupil (Leaf, Taubman, & McEachin, 2008). For these reasons some practitioners opt to use discontinuous data collection methods such as first-trial data or probe data. First-trial data collection methods involve collecting data on the pupil's response during the first trial of the teaching session only. However, it has been questioned whether this method is as accurate and as effective in reflecting progress. Cummings and Carr (2009) compared acquisition and maintenance of skills using continuous and discontinuous measurement systems using trial-by-trial data collection and first-trial only collection. A variety of motor imitation, receptive labelling, and vocal imitation skills were taught to pupils with ASD using DTT strategies. Results demonstrated pupils acquired skills in fewer sessions using discontinuous method conditions, but skills were less likely to maintain during follow-up. Skills were more likely to maintain when continuous data collection methods were used.

In a replication of the Cummings and Carr (2009) study by Najdowski et al. (2009) no such differentiations in mastery or maintenance were found when data were collected on a continuous trial-by trial basis, or on a discontinuous first trial basis. However, Najdowski et al. (2009) have suggested continuous data collection has potential advantages over discontinuous data collection as it may provide additional information and help practitioners monitor how many trials are conducted and observe details regarding prompts.

Lerman, Dittlinger, Fentress, & Lanagan (2011) evaluated the difference between continuous and discontinuous data collection procedures when teaching a range of motor imitation, instruction following, and receptive labelling skills to children with ASD or severe disabilities. Results indicated continuous data collection procedures more accurately revealed changes in performance.

In a further study Giunta-Fede, Reeve, DeBar, Vladescu, & Reeve (2016) evaluated the effects of continuous and discontinuous data collection procedures on acquisition, generalisation, and maintenance of expressive labels, and on-task behaviour. Three children with ASD were taught a range of labels during DTT sessions. Outcomes indicated labels were acquired faster when continuous data collection procedures were used, although the differences were small. Minimal to no differences were revealed across data collection procedures on the generalisation and maintenance of labelling, and on-task behaviour. Overall Giuta-Fede et al. (2016) suggest the use of continuous data collection procedures for teaching labels as it is more sensitive in identifying changes in individual's performance.

In summary, continuous data collection procedures may be more advantageous than discontinuous data collection procedures as they provide additional information, and more accurately reveal changes in performance (Cummings & Carr, 2009; Giuta-Fede et al., 2016; Lerman et al., 2011; Najdowski et al., 2009).

Mastery criteria

An important component of ABA-based teaching strategies are mastery criteria. Mastery criteria are pre-specified levels of performance which must be met before a skill is considered acquired or mastered. Via repeated learning trials individuals are required to achieve pre-specified criteria. Typically, mastery criteria are pre-specified by the practitioner setting the targets. When criteria have been achieved skills are considered acquired or mastered and the next stages of teaching are introduced. To date much of the work evaluating the effects of differing mastery criteria has been conducted with neuro-typical college students (Carlson & Minke, 1975; Fienup & Broadsky, 2017; Johnston & O'Neil, 1973; Keller, 1968; Semb, 1974). However, teaching and learning utilising mastery criteria is frequently used with individuals who are not responding to conventional teaching methods, such as those with developmental disorders or LD's. With the deficit in empirical evidence and subsequent guidance, most ABA practitioners are relying on their clinical knowledge and experience to design appropriate mastery criteria.

There is a very limited evidence base for individuals with developmental disorders or LD's looking at the effects of differing mastery criteria on skill maintenance; the extent to which an individual is able to perform a skill once an intervention is reduced or terminated. Some initial evaluations have looked at mastery criteria of 50%, 60%, 80%, 90%, and 100% correct responding, and have found skills taught to higher criteria of 80% or higher maintain more effectively over three to four weeks (Fuller & Fienup, 2017; Richling, Williams, & Carr, 2019). Results of a survey by Richling et al. (2019) found 80% mastery criteria are the most commonly used mastery criteria amongst practitioners in the field. In subsequent experiments Richling et al. (2019) evaluated the effects of mastery criteria on skill maintenance. Results suggest 80% mastery criteria may be inadequate for producing maintenance in some children, and higher criteria of 90% and 100% are more effective in producing higher levels of maintenance. Whilst these data are preliminary and further work in this area is required, outcomes could have some significant clinical implications, if 80% is found to be insufficient in maintaining skills in some children.

The differences between 80%, 90%, and 100% criteria could have implications in terms of teaching time and skill acquisition rates. If lower mastery criteria of 80% are sufficient in ascertaining mastery, and skills are found to maintain then time teaching skills could be saved. Conversely, if lower criteria result in skills failing to maintain effectually then time could be lost re-teaching non-maintained skills in future. With time and resource constraints often found in school-based settings it is essential most effective criteria are identified and utilised in order to maximise teaching. This is particularly important with ABA intervention models designed for individuals with developmental disorders and learning disabilities which deliver a lower number of direct 1:1 teaching hours (Foran et al., 2015; Peters-Scheffer et al., 2010, 2013; Pitts et al., 2019). Thus, the final study in this thesis aimed to compare the effects of three mastery criteria; 80, 90%, and 100% and their relative effects on the maintenance of skills. Whilst this study aimed to evaluate these criteria specifically, it also adds more generally to the currently limited research base into the effects of mastery criteria on the maintenance of skills with children with ASD and LD's.

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Chapter 3

~ Utilising applied behaviour analysis to teach within a special needs school[1] ~

Chapter 3 compares the effects of the school-based ABA intervention model to a control group who received EAU in a UK special needs school.

[1] This chapter has been submitted for review as 'Integrating Applied Behaviour Analysis into the curriculum improves outcomes for children with ASD in a UK Special Needs School ', by Pitts, L., Gent, S., & Hoerger, M. L.

Utilising Applied Behaviour Analysis to Teach within a Special Needs School: A Control Group Study

Abstract

Education based on applied behaviour analysis (ABA) has been demonstrated to be effective in reducing barriers to learning and improving outcomes for children with autism spectrum disorder (ASD). Research comparing an education based on ABA to education as usual within the UK is required. This study sought to compare two groups of children with ASD receiving either intervention based on ABA (n=10), or education as usual (n=10) within a UK special needs school. All children were aged between 4- and 7-years of age at intake and were assessed on intellectual development and adaptive behaviour pre-intervention and one year following intervention. Pre-intervention measures show the groups did not differ significantly at intake. After one year of intervention, children in the ABA intervention group outperformed children in the education as usual group on measures of intellectual development and adaptive behaviour. Children in the ABA intervention group made greater gains in cognition, language and communication, daily living skills, and socialisation. The ABA intervention appeared to reduce children's barriers to learning, meaning they were more able to learn effectively within the classroom. The article outlines how this ABA intervention model was effectively, affordably, and feasibly adopted within a special needs school in the UK.

There is a substantial evidence base documenting the effectiveness of interventions based on applied behaviour analysis (ABA) for individuals with special educational needs (SEN) and autism spectrum disorder (ASD) in particular. Interventions based on ABA are based in operant learning theory. Skills are broken down into small, teachable units and prompts are used to facilitate learning. Teachers reinforce correct responding during skill acquisition and generalisation and then systematically reduce reward until the skill is maintained by naturally occurring reinforcement. Modern applications of ABA differs from behaviour modification. Board Certified Behaviour Analysts (BCBA's) consider the context and function of behaviour and seek to create an environment which facilitates learning. While BCBA's utilise reinforcement, equal consideration is given to context, and each child is considered as an individual.

Children with ASD and related disorders often present with barriers to learning which can include difficulties with language, attention, cooperation, imitation and social interaction, as well as challenging or disruptive behaviour (Najdowski, Gould, Lanagan, & Bishop, 2014; Pitts, Gent, & Hoerger, 2019). When compared to standard or education as usual (EAU), interventions based on ABA have been demonstrated to be more effective in reducing barriers to learning by developing language and communication, cognitive skills, and adaptive behaviour in children with ASD (Eikeseth, Smith, Jahr, & Eldevik, 2007; Eikeseth et al., 2009; Eikeseth, Smith, Jahr, & Eldevik, 2002; Eldevik, Eikeseth, Jahr, & Smith, 2006; Grindle et al., 2012; Petters-Scheffer, Didden, Mulders, & Korzilius, 2010, 2013).

Much of the literature on ABA evaluates Early Intensive Behavioural Interventions (EIBI), which entail 20 to 40 hours of 1:1, direct teaching based on the principles of ABA per week. Programmes are individually designed for each pupil and utilise behaviour analytic procedures such reinforcement, prompting and prompt fading, error correction, and generalisation. Typically, discrete trial teaching procedures are used alongside natural environment teaching procedures (Smith, 2001). Functional behaviour assessments are often used to develop function-based behaviour support plans aimed to reduce behaviours which may be harmful or interfering with the child's ability to learn. A behaviour analyst typically supports tutors and parents to deliver the intervention within the child's home (Granpeesheh, Tarbox, & Dixon, 2009). Interventions can be provided at a centre rather than at home, however within the UK centre based interventions are less common. Home-based programmes involve the delivery of teaching and learning sessions following the principles of ABA, with carefully planned transitions across other environments within the community and education settings, such as schools and nurseries (Grindle et al., 2012; Roberts et al., 2011).

The delivery of 20-40 hours of 1:1, direct teaching isn't always practical or desirable. High levels of 1:1 teaching may be incompatible with the teaching culture and pedagogy in UK special needs schools. The cost of delivering 20-40 hours of 1:1 teaching may be prohibitive to many families and local authorities, the availability of professionals to provide interventions is also limited (Johnson & Hastings, 2002). School-based interventions in which teaching based on the principles of ABA is delivered across the school day in a variety of settings, but with fewer hours per week of direct 1:1 teaching may be an effective alternative. School-based ABA interventions are beginning to be evaluated with promising outcomes, with many pupils demonstrating significant gains in adaptive skills and reductions in harmful behaviours. (Foran et al., 2015; Peters-Scheffer et al., 2010, 2013; Pitts et al., 2019).

There is an emerging research base for an alternative delivery model of ABA in schools. In these models, a BCBA collaborates with teachers and classroom assistants to integrate ABA teaching throughout the school day using typical staffing levels. In the model the children have fewer hours of 1:1 teaching than on traditional EIBI programmes, but the ABA teaching is integrated across the school day. The teaching staff create opportunities for children to practice their skills and receive feedback during all school activities. Foran et al. (2015) evaluated ABA interventions delivered in a UK maintained SEN school. Thirteen children between the ages of 4- and 6-years participated. Eight children had a diagnosis of ASD, three a diagnosis of social communication disorder, and two a diagnosis of pervasive developmental disorder not otherwise specified. The authors described the model; in which a multi-disciplinary team; including teachers, teaching assistants, speech and language therapists, and behaviour analysts worked in collaboration to deliver ABA-based teaching and behaviour support. Children were supported all day using the principles of ABA in class by trained teachers and teaching assistants. Trained staff also implemented individual education programmes and function-based behaviour support plans. Staff provided approximately seven hours of direct 1:1 teaching per week per pupil and created learning opportunities to encourage the generalisation of skills taught within 1:1 teaching sessions to the classroom and around school. Daily living skills such as eating a balanced diet, toileting, and dressing were also targeted throughout the day using ABA principles. Measures of IQ and adaptive behaviour were used to assess all children at baseline and again after one academic year of intervention. Results demonstrated increases in IQ and adaptive behaviour with statistically significant increases in communication and daily living skills. Whilst these results are promising, further research into the model is required; extension across cohorts, schools, and the inclusion of a control group would be particularly valuable in evaluating this model.

Other control group studies conducted within school settings in the Netherlands have revealed some encouraging outcomes; studies by Peters-Scheffer et al. (2010, 2013) evaluated the effectiveness ABA intervention with children ages 3- to 7-years old with ASD and intellectual disabilities. All children were enrolled in public preschools or schools for children with intellectual disability. The ABA intervention groups received between four and ten hours of 1:1 ABA-based teaching per week. The control groups received regular intervention or education as usual (EAU). Following intervention, children in the ABA intervention groups demonstrated significantly higher developmental ages and made more gains in adaptive skills than children in the control groups. Increases in receptive language, interpersonal relations, and play skills were observed. Whilst initial evaluations of ABA interventions conducted within UK SEN schools have demonstrated similar positive effects on adaptive behaviour (Foran et al., 2015; Pitts et al., 2019), comparison studies which include a control group are still required. The current study aims to compare the outcomes of ABA intervention to EAU delivered in a UK SEN school. The study utilises a control group design to evaluate the effects of ABA intervention in comparison to EAU. Twenty pupils aged 4- to 7-years old with a diagnosis ASD and intellectual disabilities participated in the research. The ABA intervention group received the type of provision described by Foran et al. (2015) and Pitts et al. (2019), with children supported by teachers and teaching assistants using the principles of ABA and receiving individual behaviour support and education plans. The outcomes of one group of children following one full year of ABA intervention will subsequently be presented and compared to a group of children who received EAU.

Columbus School and College

Columbus School and College is an academy day school located in the South East of England. The school caters for pupils between 3- and 19-years of age with a wide range of physical disabilities, developmental disorders, and learning difficulties.

The Model

Behaviour analysts and school-based staff incorporated techniques from ABA into standard educational provision for pupils with ASD and other developmental disorders, disabilities, and learning difficulties. One BCBA and one assistant behaviour analyst worked with school staff to design and implement individual programme targets and behaviour support plans. The model is described in further detail in Foran et al. (2015) and Pitts et al. (2019).

Method

Design

A non-randomised pre-test/post-test control group design was employed to assess the effects of the intervention. Prior to baseline assessments being conducted the school senior leadership team allocated pupils to either an ABA intervention group or a control group. The leadership team assigned pupils to the intervention group using two main criteria: 1) the pupil was not making progress as measured by school-based assessments and 2) the pupil engaged in behaviours which were harmful and/or interfering with their ability to learn. There were some data which the leadership team used to make decisions on group assignment, however, it was not comprehensive or consistent enough to present.

Whilst random assignment to group would have been ideal, it wasn't possible in this setting for ethical reasons relating to withholding a potentially effective intervention from pupils who were progressing least and engaging in the most harmful behaviour.

Participants

Twenty pupils participated (Table 1). The intervention group and control group each comprised of 10 pupils. All pupils had a diagnosis of ASD, a comorbid learning disability, and 70% of pupils in the intervention group and 40% of pupils in the control group had additional diagnoses, including developmental disorders arising from chromosomal abnormalities, sensory processing disorder, global developmental delay, and epilepsy. The participants had not received any education based on ABA prior to the study. One participant was not available for one of the post-test measures; the Mullens Scales of Early Learning.

Table 1

Participant data

Class	N	Gender	Mean age	Range
Intervention Group	10	1 female, 9 males	74.4 months	52-91 months
Control Group	10	2 females, 8 males	69.1 months	52-91 months

Measures

The following measures were used to access intellectual development and adaptive behaviour.

Intellectual Development. The Mullen Scales of Early Learning (MSEL: Mullen, 1995) was conducted with all pupils pre- and post- intervention by an assessor who was independent of the study and blind to the participants assignment to group. The MSEL is a standardised, direct assessment which measures the intellectual development of children from birth to 68 months of age. This assessment is commonly used for children with ASD and other developmental disabilities. The chronological age of some pupils was above the standard age range for which the assessment was developed, and some raw scores were lower than the lowest standardised score provided, therefore we used standardised Developmental Quotients (DQ). The DQ is calculated by dividing the age equivalent score by the child's chronological age in months and multiplying by 100. The use of DQ helps control for the effects of age and maturation. The MSEL age equivalent scores are based on typical development. A child who was on a stable developmental trajectory would not show a change in DQ over one year. Children who gained skills faster than expected will display an in increase in DQ, and children who learn at a slower rate than typical will show a decrease in DQ. Using scores in this way is becoming standard practice for researchers and clinicians who work with children with intellectual disabilities and developmental delays (Bishop, Guthrie, Coffing, & Lord, 2011; Dawson et al., 2010).

Mullen (1995) reports good internal test-retest, interrater reliability for the MSEL. The MSEL is becoming more commonly used in research and clinical evaluations of children with ASD (Bishop et al., 2011). There is a growing precedence for using the MSEL to evaluate ABA-based interventions with children with ASD (e.g. Dawson et al., 2010, Flanagan, et al., 2012; Peters-Scheffer, et al., 2013; Rogers et al., 2012; Schreck, Metz, Mulick, & Smith, 2002; Smith, Groen, & Wynn, 2000; Smith et al., 2015; Vivanti et al., 2014).

Adaptive Behaviour. The Vineland Adaptive Behaviour Scale (VABS: Sparrow, Balla, & Cicchetti, 2005) was conducted with all pupils pre- and post- intervention. The VABS provided a measure of pupils' communication, daily living skills, socialisation, motor skills, and maladaptive behaviour. Adaptive behaviour composite scores were generated along with standard scores and age equivalents for communication, daily living skills, socialisation, and motor skills (motor skills were only accessed for individuals under 7-years of age). The VABS was completed through conducting semi-structured interviews with pupil's class teachers. The post-test assessments were conducted by an assessor who was independent of the study and blind to the conditions. As with the MSEL the VABS is a normed measure based on typical development. An increase on VABS scores indicates a child is gaining skills more rapidly than would be expected after a typical year of development. The VABS is commonly used a measure of adaptive behaviour skills and is reported to have good internal consistency, interrater reliability and content validity (Sparrow, et al. 2005). There is a precedence for using the VABS in evaluations of ABA-based interventions for children with ASD (e.g. Cohen, Amerine-Dickens, & Smith, 2016; Dawson et al., 2010; Eikeseth et al., 2002, 2007; Eldevik, et al., 2006, 2012, 2019; Flanagan, Perry, & Freeman, 2012; Grindle et al., 2012; Howard, Sparkman, Cohen, Green, & Stanislaw, 2005; Howard, Stanislaw, Green, Sparkman, & Cohen, 2014; Peters-Scheffer, et al., 2010, 2013; Rogers et al., 2012; Sallows & Graupner, 2005; Smith et al., 2000, 2010; Smith, Klorman, & Mruzek, 2015; Vivanti et al., 2014).

The MSEL and VABS were conducted with all pupils prior to intervention and again 12 months following intervention.

Procedure

All pupils in both the ABA intervention group and the control group attended school for 30 hours per week. Both groups received group lessons based on national curriculum subjects. National curriculum subject lessons were planned and taught by class teachers. All pupils received their usual sessions in motor therapy rooms, sensory rooms, soft play, and swimming, and all participated in school-based activities such as assemblies, school plays, and community trips.

Control Group. The control group received education as usual (EAU) which was education based on the national curriculum and the school's own key skills curriculum. The key skills curriculum is designed to intertwine subject specific learning experiences with opportunities to develop communication skills, problem solving skills, motor development, independence and social skills, personal, social and health skills, communication skills, applying and using mathematics, motor development, information technology skills, study skills, and problem-solving skills. Targets for all pupils in the EAU group were set by their class teacher, Speech and Language Therapist, and Occupational Therapist as appropriate. The pupils in the control group were based in different classrooms with different staff teams to the pupils in the intervention group.

ABA Intervention Group. A BCBA and a master's level behaviour analyst collaborated with class teachers and teaching assistants to deliver ABA-based educational and behavioural intervention programmes. To become a BCBA a candidate must complete 315 hours of postgraduate coursework, undergo 1500 hours of supervised fieldwork, pass a qualifying exam, agree to the code of ethics, and complete ongoing continuing education with specific requirements for continuing education in ethics (Behavior Analyst Certification Board, 2019).

The ABA intervention group received an average of five hours of 1:1 teaching per week, delivered by teachers and teaching assistants who had received training in ABA. Discrete trial and natural environment teaching strategies were used to deliver individual programme targets. Twenty to thirty minute 1:1 teaching sessions were provided across the school day. A timetable of sessions was set up so pupils could carousel between 1:1 sessions and group teaching sessions. Outside of 1:1 lessons, teacher:pupil ratios were approximately 0.5:1.

Teachers and teaching assistants implemented individualised function-based behaviour support plans designed to reduce behaviours which were harmful or were interfering with a pupils ability to learn. Self-stimulatory behaviours were not targeted for reduction unless the behaviour was causing harm to the pupil, for example if a pupil engaged in eye gouging, we would encourage them towards a less harmful behaviour that satisfied the sensory need. Functional communication programmes which taught pupils to request for desired items and activities were also implemented. Staff worked throughout the day to promote the generalisation of skills learnt within 1:1 sessions within group sessions in classroom as well as around school. For example, these sessions included generalising requesting skills at playtime, snack time and lunch time, matching food and cooking utensil's during food technology lessons, receptively identifying and labelling items in the garden, following instructions in the gym during P.E or in music lessons, soft play or motor therapy.

Throughout the school, day daily living skills, such as eating, dressing and personal hygiene skills including toileting, hand washing, and mouth and nose wiping were also targeted. Some mealtime programmes were developed by the behaviour analyst for children who required support to develop skills such a drinking from a cup, drinking from a straw, and using utensils. The behaviour analyst also designed some eating programmes based on positive reinforcement and shaping for several pupils who were displaying food selectivity issues.

Individual Programmes. Using the outcomes from initial assessments, behaviour analysts developed individual education programmes. Curricula goals were derived from the Assessment of Basic Language and Learning Skills- Revised (ABLLS-R; Partington, 2006). Communication and the development of 'learning to learn' skills (such as attention, cooperation, imitation, visual performance, and listening skills), self-help (toileting, dressing, and eating skills), independence, and play and social skills were the focus of all programmes. Academic skills were introduced after pupils had acquired some essential 'learning to learn' or prerequisite skills such attention, cooperation, listening skills, imitation, and visual performance skills.

Behaviour analysts designed individualised function based behaviour support plans for each pupil. The aim of these plans were to reduce behaviours which were harmful or were interfering with a pupils ability to learn. The behaviour analysts conducted functional assessments which helped identify why a pupil engaged in the behaviour. Triggers or variables which occasion behaviour (antecedents), as well as variables maintaining behaviour (consequences) were identified. Function-based behaviour support plans were designed to reduce behaviour by eliminating variables which occasioned behaviour and arrange consequences which increased more appropriate behaviour. On-going data were collected on incidences of behaviour, thus providing a way of monitoring the effects of interventions. Behaviour support plans were also reviewed and adjusted as required based on the data collected by staff and following collaboration with staff implementing the plans.

Teaching. The ABA intervention model employed the following teaching strategies: reinforcement, prompt and prompt fading, error correction, discrete trial teaching, natural environment teaching, and task analysis and chaining.

Reinforcement. Reinforcement strategies were core to the interventions. Reinforcement is a process by which a stimulus is presented contingent upon a specific response consequently increasing the probability of the response reoccurring in future (Cooper, Heron & Heward, 2007). Reinforcement strategies were employed to increase engagement in a range of behaviours, such as communication, attention, social interaction, and correct responding during teaching and learning sessions. Reinforcement was employed in the form of social praise and access to preferred tangible items or activities (for example, the opportunity to play with a preferred toy, ride a bike, jump on a trampoline, use a computer or iPad). Tangible items were always paired with social praise so that social praise would begin to function as a reinforcer for the pupils. Under no circumstances were punishment procedures recommended or used.

Prompting. Prompts were used to assist pupils to respond correctly; instructions, gestures, touches, and demonstrations were used to increase correct responding. Prompting pupils to the correct response meant responses could be reinforced (resulting in an increased probability of the responses occurring in future). To encourage independent responses prompts were gradually faded during teaching.

Error Correction. If a pupil responded incorrectly error correction procedures were employed. Following an incorrect response, the teacher would reissue the instruction and immediately prompt the correct response. The same instruction was repeated to give the pupil the opportunity to respond independently.

Discrete Trial Teaching (DTT). Skills were broken down into a sequence of prerequisite steps and taught consistently and systematically to a pre-set mastery criterion. Reinforcement, prompt and prompt fading strategies were used to teach each skill. Each trial had a distinct beginning, middle and end. Each step of a skill was mastered before new concepts were introduced. Sessions were structured so repeated learning trials could be presented. Five hours of DTT was provided per pupil per week.

Natural Environment Teaching (NET). These sessions focused more directly with the pupil's own interests and preferences. Staff utilised naturally occurring 'incidents' to create learning opportunities. The learning environments were organised whilst taking into account the pupil's individual motivations; so when pupils demonstrated interest in an item or activity, staff could encourage that interest and create learning opportunities around it. NET sessions were used to teach new targets and generalise mastered skills.

Task Analysis, Shaping and Chaining Strategies. Task analysis and chaining strategies were also employed. A task analysis breaks down a complex skill or sequence of behaviours into smaller more teachable steps. Initial baselines were established by observing the pupil engaging in the task to see if they could complete any of the steps, and unknown steps were then identified for teaching in sequential order. Prompt and prompt fading strategies were used to facilitate teaching. These strategies were used to teach skills such as hand washing, toileting and dressing. Finally, shaping strategies were used to improve behaviours such as speech. Shaping involves differentially reinforcing successive approximations of a target behaviour (Smith, 2001). For example, teachers gradually shaped speech sounds or words using differential reinforcement (i.e. responses closer to the target behaviour in this case the sound resulted in higher levels of reinforcement, whereas weaker responses received little if any reinforcement).

Skill acquisition and generalisation. Skills were practiced and mastered across a variety of situations and settings. Different members of staff worked with each pupil and teaching materials and specific instructions were varied to aid generalisation. Skills were considered mastered when they met a mastery criteria of at least 80% correct, over three consecutive sessions, and at least two different members of staff.

Skill maintenance. Where possible, mastered skills were generalised so they would maintain in the natural environment; these included communication skills such as requesting, and self-help skills, such as toileting, dressing, and eating. Skills which required specific maintenance (e.g. academic skills) were moved to maintenance programmes, where learning opportunities were presented at regular intervals (e.g. once per week). To aid acquisition of new targets, reinforcement was delivered frequently; once skills were mastered and moved to maintenance intermittent reinforcement was utilised.

Data Collection. Data were collected by teaching staff on a trial by trial basis on all acquisition targets, behaviour analysts reviewed data, adjusted targets and made curricular changes based on these data.

Staff Training. The behaviour analysts provided training and ongoing supervision in ABA interventions. Approximately 50% of the staff had one academic year's experience of delivering this model, the rest had no prior experience of implementing the model. Theory training was provided by the behaviour analysts in a lecture-style format with opportunities for discussion, and videos were used to demonstrate specific teaching and learning strategies. On-site in the classroom behaviour analysts delivered practical training which utilised behavioural skills training procedures to train staff in the strategies outlined in the previous section. Behavioural skills training involved delivering instructions, modelling skills, providing opportunities for rehearsal of skills and providing feedback during and after practice (Parsons, Rollyson, & Reid, 2012; Miles & Wilder, 2009; Sarokoff & Sturmey, 2006). Behaviour analysts used staff training checklists and procedural integrity checklists to establish, track and master skills. Following the practical training, monthly follow-up sessions were conducted to monitor staff and deliver further training and support on specific strategies. The staff with one academic year's experience of delivering this model were also provided with the monthly follow ups.

Supervision and Consultation. During the course of the academic year behaviour analysts and school staff monitored pupils progress, updated behaviour support plans and individual teaching programmes and targets. The behaviour analysts were on-site approximately once per week to do this, as well as provide further staff training and support. Each pupil received an average of three hours per month of input from a behaviour analyst.

Procedural Integrity. A series of procedural integrity checks were used to ensure teaching strategies were implemented as designed. Behaviour analysts directly observed the teaching staff and used checklists to access the correct implementation of strategies. For discrete trial teaching each component of the teaching was assessed (e.g. attention, discriminative stimulus, prompts, prompt fading, error correction, reinforcement, teaching pace, etc.). Checks for teaching sessions were conducted across the academic year; once after two months of intervention and once again after ten months of intervention. Procedural integrity was calculated by dividing the number of correct steps implemented by the total number of steps completed. See table 2 for results.

Procedural integrity checks were also completed for the implementation of behaviour support plans to ensure each component of a behaviour support plan was being implemented as designed. Checks were made once after two months of intervention and once after ten months of intervention. Staff were observed within the classroom and a checklist was used to record whether each proactive and reactive strategy was being implemented correctly. Procedural integrity was calculated by dividing the number of correct strategies implemented by the total number of strategies outlined on the behaviour support plan. Results are displayed in Table 2.

Table 2

Mean procedural integrity item scores

Procedural Integrity Item	Percentage (SD)
1:1 discrete trial teaching sessions after two months	72.72% (13.75)
1:1 discrete trial teaching sessions after ten months	90.90% (4.86)
Behaviour support plans after two months	73.87% (10.24)
Behaviour support plans after ten months	88.64% (6.43)

Mean= mean question item score, SD = standard deviation

Social Validity. Social validity was assessed by administering questionnaires to class teachers and teaching assistants in the intervention group. All eight invited respondents anonymously completed the questionnaires. Respondents were asked to evaluate interventions by rating items on a scale of 1 to 5 (1 = strongly disagree and 5 = strongly agree). Results are displayed in table 3.

Table 3

Mean social validity questionnaire item scores

Questionnaire Item	Mean (SD)
Sufficient staff training was provided	4.375 (0.355)
Staff were comfortable implementing 1:1 teaching and learning sessions	4.000 (0.756)
ABA placed pressure on classroom staff	2.125 (0.641)
Pupils were properly assessed and planned for	4.375 (0.355)
Pupils were regularly monitored	4.625 (0.744)
Targets were adjusted when required	4.125 (0.835)
Programmes were simply trying to teach skills that all pupils needed to learn	4.750 (0.463)
The focus of the programmes was on increasing positive behaviour	4.375 (0.463)
Pupils benefit from ABA interventions	4.875 (0.354)

Mean= mean question item score, SD = standard deviation

Results

Changes in scores between time one and time two data were analysed for both the intervention group and control group using analyses of variance (ANOVA's) to check for main effects of time and group, and interactions for time and group. Primary outcome measures comprised of the MSEL composite score and the VABS composite scores. Further analysis using independent samples t-tests were run to determine if the groups were similar before the start of the intervention, and paired samples t-tests were conducted to analyse if the groups showed significant gains following one year of education. The same analysis were conducted on the subscales for each measure. Effect size was calculated and interpreted using Cohen's d formulations and conventions.

Primary Outcome Measures

Intellectual development- MSEL Composite Scores. ANOVA results revealed a main effect of time ($F(1, 17) = 48.75$, $p < 0.001$) and group x time interaction ($F(1, 17) = 50.86$, $p < 0.001$). The intervention group demonstrated a significant increase in intellectual development and made more gains than the control group (Table 4). An independent samples t-test revealed that the intervention group ($M=10.39$, $SD=7.99$) and control group ($M=12.69$, $SD=6.03$) did not differ significantly at the start of the intervention. A further paired samples t-test showed that the intervention group made significant gains following one school year of ABA intervention $t(-8.8)$, $p<.001$. The control group did not show a change in scores on the MSEL Composite Score after one year of treatment as usual. See Table 4.

Adaptive behaviour- VABS Composite Scores. ANOVA outcomes indicated a main effect of time ($F(1, 17) = 44.66$ $p < 0.001$) and a group x time interaction ($F(1, 17) = 48.51$, $p < 0.001$). The intervention group presented with significant increases in adaptive behaviour and made greater improvements than the control group (Table 4). The average score on the VABS composite measure was similar for the intervention group ($M=50.78$, $SD=11.72$) and the control group ($M=50.30$, $SD=7.39$) at baseline, and an independent samples t-test confirmed that these means were not significantly different from one another. Following one school year of intervention based on ABA, an paired samples t-test showed that the intervention group score showed a statistically significant increase $t(-7.13)$, $p<.001$. The VABS composite scores for the control group remained unchanged.

Table 4

Primary outcome measures- MSEL and VABS after one year of intervention.

Measure	**Time 1 and Time 2 Outcomes**								**Group Comparison**					
	Intervention Group				Control Group				Time			Time x group Interaction		
	Time 1		Time 2		Time 1		Time 2							
	M	SD	M	SD	M	SD	M	SD	F	P	ES	F	P	ES
MSEL Composite	10.39	7.99	19.26	7.63	12.69	6.03	12.60	6.77	48.75	.000	3.39	50.86	.000	3.46
VABS Composite	50.78	11.72	60.44	10.86	50.30	7.39	50.10	7.99	44.66	.000	2.24	48.51	.000	3.38

F= f value , P= p value, EF= effect size, SD = standard deviation

Secondary Outcome Measures

Intellectual development- MSEL Subscales. ANOVA results indicated a significant main effect of time ($F(1, 17) = 42.15$, $p < 0.001$) and group x time interaction ($F(1, 17) = 28.26$, $p<0.001$) for the language DQ. A main effect of time ($F(1, 17) = 7.45$, $p= 0.009$) and significant group x time interaction ($F(1, 17) = 20.57$, $p= 0.001$) was found for the cognitive DQ (Table 5). Independent samples t-tests found that the groups did not differ before the intervention. Paired samples t-test confirmed that the intervention group showed significant increases on both the language scales t(-8.22), $p<.001$) and cognitive scales t(-4.29), $p<.01$ after a year of ABA education. The control group scores on both subscales did show significant change after one year of treatment as usual.

Adaptive behaviour- VABS Subscales. ANOVA outcomes denoted a time effect ($F(1, 17) = 30.45$, <0.01) and group x time interaction ($F(1, 17) = 36.61$, $p< 0.01$) for communication. A main effect of time was found for the daily living skills subscales ($F(1, 17) = 18.51$, $p= 0.001$)

and group x time interaction (F (1, 17) = 30.19, p< 0.001). A main effect of time was also found for the socialisation subscale (F (1, 17) = 20.33, p= 0.001) and group x time interaction (F (1, 17) = 26.03 p= 0.001) was also revealed (Table 5). On all three subscales, independent sample t-tests showed the groups did not show significant differences at pre-test. The participants in the intervention group made statistically significant increases on the communication t(.68), p<.001; daily living skills t(-4.9), p<.01; and socialisation subscales t(-6.3), p<.01. The control group did not show significant changes on any of the subscales.

Table 5

Secondary outcome measures- MSEL and VABS Subscales after one year of intervention.

Measure	**Time 1 and Time 2 Outcomes**								**Group Comparison**					
	Intervention Group				Control Group				Time			Time x group Interaction		
	Time 1		Time 2		Time 1		Time 2							
	M	SD	M	SD	M	SD	M	SD	F	P	ES	F	P	ES
MSEL Language DQ	10.62	8.70	21.33	9.04	14.73	8.27	16.01	10.19	42.15	.000	3.15	28.26	.000	2.58
MSEL Cognitive DQ	10.16	7.52	17.18	7.44	10.65	4.72	9.18	4.47	7.45	.009	1.33	20.57	.001	2.20
VABS- Com	44.00	11.00	59.22	11.74	48.00	7.96	48.10	9.46	30.45	.000	2.68	36.61	.000	2.94
VABS- DLS	45.77	10.25	58.11	10.55	50.50	11.09	49.00	10.86	18.51	.001	2.09	30.19	.000	2.67
VABS- Social	47.77	4.2	55.89	3.88	52.30	5.14	51.80	6.97	20.33	.001	2.19	26.03	.001	2.48

F= f value , P= p value, ES= effect size, SD= standard deviation

Discussion

Ten pupils with ASD receiving school-based ABA intervention were compared to a control group of 10 pupils with ASD receiving EAU in a SEN school. The pupils in the ABA intervention group made greater gains on standardised measures of intellectual development and adaptive behaviour than their peers who received a more typical education.

The intervention group outperformed the control group on skills measured by VABS, including communication, daily living skills, and socialisation. The VABS is a standardised assessment tool and if normative levels of progress had been made the scores would have been the same at post-test as they were at pre-test. However, the intervention group scores were higher at post-test suggesting normative expectations of progress were exceeded. In comparison to the control group greater gains in adaptive behaviour were observed for pupils in the intervention group. The outcomes from the MSEL also revealed the intervention group exceeded the control group with statically significant increases demonstrated on both measures of language and cognitive skills.

Overall outcomes suggest ABA intervention lead to reductions in barriers to learning and increases in adaptive skills. Following ABA intervention pupils engaged in less maladaptive behaviour, established additional appropriate replacement behaviours, and were more adept in functionally getting their needs met. Consequently, pupils were able to engage in more learning tasks as they were presented, and more able to participate and learn within their classroom. Pupils were better able to partake in early learning tasks, such as imitation tasks and visual performance activities including; matching, sorting, patterning, sequencing, categorising, and memory tasks. Pupils also learnt and developed independence with essential daily living skills, such as toileting, eating, and dressing skills. The results are in line with previous research (Foran et al., 2015; Pitts et al., 2019) showing that pupils who received an intervention that included ABA across the school day made significant increases in adaptive behaviour, with statistically significant increases observed in both communication and daily living skills.

Research in EIBI has shown children who receive fewer hours of 1:1 teaching do not make the same gains as children on higher intensity programmes (Lovaas, 1987; Eldevik, Titlestad, Aarlie, & Tonnesen, 2019). In EIBI programmes all ABA teaching is delivered in a 1:1 format, and therefore a child who receives 10 hours of 1:1 teaching a week only receives 10 hours of ABA teaching a week. In the current model, ABA is delivered using a combination of 1:1 teaching and group instruction to increase learning opportunities. Whilst 1:1 teaching hours are imperative to most pupils acquiring new skills, other components of the ABA model adopted within this study are also likely to have played a significant role in observed progress. Individualised behaviour support played a role in reducing harmful behaviour and increasing functional communication and skills. Having all teaching staff trained in ABA supporting pupils throughout the day, meant additional practice opportunities outside 1:1 teaching session times, and more opportunities for the generalisation of skills across setting, staff and materials. The children in the current study received only five hours a week of 1:1 teaching but received 30 hours of teaching each week based on the principles of ABA. This is an emerging evidence base on alternative applications of ABA for young children with autism.

The current research provides a practical demonstration of how ABA intervention can be affordably and practically implemented. It has been suggested that estimated long-term savings of early intensive behavioural intervention far outweigh the initial costs, however procuring funding for behavioural intervention is still highly challenging (Chasson, Harries, & Neely, 2007; Jacobson, Mulick, & Green, 1998; Peters-Scheffer, Didden, Korzilius, & Matson, 2012). A cost-benefit analysis is required to evaluate the model described in this paper. If the model is found to be cost effective then it is hoped that it leads to more pupils accessing more effective and long-term more beneficial intervention.

The study does have its limitations including its small sample size and the absence of a fully randomised control trial design. Assignment to the ABA intervention group instead was based on decisions made by the school leadership team using information regarding behaviours of concern and academic progress. It was not possible in this setting to implement a fully randomised control trial design. Future research should explore larger sample sizes and the use of random assignment to groups where possible. The ABA intervention lasted one academic year and focused specifically on reducing barriers to learning. Future research should consider if and how pupils continue to benefit from an ABA intervention over several years.

The study does have various strengths and its rigor is increased by the post-test VABS assessments and pre and post-test MSEL assessments being conducted by a practitioner who was both blind to conditions and independent of the study. Measures of procedural integrity and social validity add to the studies strength, as does high social validity outcomes.

Finally, the study helps bridge the research and practice gap by demonstrating ABA intervention can be implemented effectively within an existing school setting. It has provided a rare demonstration of how a group of pupils receiving ABA intervention benefitted from and made more progress than pupils receiving EAU within a SEN school in South East England. Whilst further comparison to EAU evaluations are required, this initial evaluation provides promise for a model which is effective, affordable, and feasible for schools implement.

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Chapter 4

~ Utilising applied behaviour analysis to teach within a special needs school: Applications with older children across the key stages [2] ~

Chapter 4 further evaluates the school-based ABA intervention model utilised in chapter 3, whilst extending the work across the key stages to include a wider age range of children and young people.

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Reducing Pupils Barriers to Learning in a Special Needs School: integrating Applied Behaviour Analysis to teach Key Stages 1-3

Abstract

This study evaluated the effectiveness of applied behaviour analysis (ABA) intervention for pupils with Autism Spectrum Disorder and additional learning difficulties within a UK special needs school. The study utilised a group design to evaluate the effects of ABA interventions designed to reduce barriers to learning with individuals aged four to thirteen years of age. Behaviour analysts worked with school-based teaching teams to design and implement function based behaviour support plans, individual education programmes, utilise ABA teaching strategies, and promote the generalisation of skills. Pupils were assessed at baseline and again following one academic year of intervention using the Assessment of Basic Language and Learning Skills, Early Years Foundation Stage and P-scale assessments, Vineland Adaptive Behaviour Scales, and the Behaviour Problems Inventory. Following one academic year of intervention pupils demonstrated significant gains in learning skills, language and communication, social and play, and self-help skills. Pupils of all ages acquired essential 'learning to learn' skills which have reduced their barriers to learning and are enabling them to learn more effectively within school. The article discusses how a behavioural model was successfully and affordably employed across key stages within a special educational needs school.

In England, the Department for Education (DfE) recommends all pupils access a broad and balanced curriculum. Teachers are advised to administer appropriate assessments, use assessment outcomes to set academic targets, and attempt to remove barriers to learning (Department for Education, 2015). Barriers to learning are defined as behaviours which may cause harm or interfere with individual's ability to learn. Children with SEN, including those with Autism Spectrum Disorder (ASD), may present with significant barriers to learning such as difficulties with language, sustained attention, imitation, cooperation, and social interaction, which are all prerequisites to learning effectively from the natural environment (Najdowski, Gould, Lanagan, & Bishop, 2014). Children with SEN may also present with challenging or disruptive behaviours in the classroom which interfere with learning.

Interventions based on Applied Behaviour Analysis (ABA) have been shown to be effective in reducing barriers to learning by teaching prerequisite skills for learning while reducing challenging behaviours. Children with ASD who receive an Early Intensive Behavioural Intervention (EIBI) application of ABA have been shown to make greater gains on measures of IQ, learning, language, and adaptive functioning than children who receive a treatment as usual (Eikeseth, Smith, Jahr, & Eldevik, 2002; Lovaas, 1987; McEachin, Smith, & Lovaas, 1993; Sheinkopf & Siegal, 1998; Smith et al., 1997). EIBI programmes target a comprehensive range of adaptive skills. Behavior analysts design and implement bespoke educational programmes and behaviour support plans based on outcomes of skill assessments and functional behaviour assessments. Children are typically between the ages of two and six years old at the beginning of the intervention and receive 20- to 40-hours of 1:1 direct teaching per week (Granpeesheh, Tarbox, & Dixon, 2009). For many children with ASD, this level intervention isn't always feasible or practical. The accessibility of EIBI may be impeded by financial costs, issues sourcing funding from local education authorities, and family circumstances. The availability of trained professionals to deliver interventions can also limit accessibility (Johnson and Hastings, 2002).

An emerging literature on evaluations of applications of ABA interventions within schools have demonstrated positive results (Eldevik, Eikeseth, Jahr, & Smith, 2006; Peters-Scheffer, Didden, Mulders, & Korzilius, 2010). Grindle et al. (2012) evaluated ABA interventions within an autism-specific class in a UK mainstream school with children aged between three and seven years old. The children made significant gains on standardised measures of IQ and adaptive behavior with moderate to large effect sizes following a year of ABA intervention. Statistically significant gains in adaptive skills were observed for those children who participated in ABA intervention compared to a group of children who received EAU.

Foran et al. (2015) studied the effects ABA interventions delivered within in a UK special needs school setting. A group of seven children with ASD under seven years old were supported in class by staff trained in the principles of ABA, all children had individual education plans and function-based behaviour support plans. The children received an average of 7 hours of 1:1 teaching per week and were supported by trained staff in a ratio of 0.56:1 for the remainder of the time. Following one school year of ABA intervention, the children made significant gains on measures of IQ, language, social and play skills, and academic skills. Subsequent decreases in challenging behaviour were also observed following function-based behavioural intervention.

Many of the recent studies into the effectiveness of school-based ABA interventions have included young children up to seven years old (Eldevik et al., 2006; Foran et al., 2015: Grindle et al., 2009; Peter Scheffer et al., 2010). An emerging literature has shown that ABA interventions can be effective for older children and young people. Lambert-Lee et al. (2015) describe a comprehensive ABA model delivered within an autism-specific school within the UK. All pupils had individual education plans and function based behaviour support plans. Pupils were taught using a combination of 1:1 teaching and group teaching. Support was provided throughout the school day by trained ABA tutors who were educated to a degree level. Interventions were designed and overseen by an ABA supervisor and an ABA consultant. All staff within school were trained in the principles of ABA. Data from a 12-month period were analysed from 53 pupils with ASD between six and eighteen years of age, and all pupils made significant gains on measures of curriculum and adaptive behaviour.

The scope and focus of the research evaluating ABA interventions for older children and young people tends to be significantly narrower than that conducted with younger children. The focus with younger children has been to address a comprehensive range of behaviour or skill deficits, whereas the focus of most ABA interventions for older children and young people has been to address more specific deficits or behaviours; typically a specific skill or small range of skills (Granpeesheh et al. 2009). Interventions based on ABA for older students have been shown to be effective at: reducing specific challenging behaviour (Durand, 1999), developing specific skills such as communication (Schepis et al. 1982), social skills (Haring & Breen, 1992), and contextually appropriate affective behaviour (Gena, Krantz, McClannahan, & Poulson, 1996). In a meta-analytic review of 43 single case research studies, behavioural interventions for young people and adults with ASD resulted in medium to strong effect sizes for outcomes of interventions designed to improve academic, adaptive, social and vocational skills, and challenging behaviour (Roth et al., 2014).

Whilst the studies outlined demonstrate ABA interventions with older children and young people are effective in improving specific behaviours and skills, evaluations of larger more comprehensive interventions which target a range of skills, including barriers to learning are rare. Barriers to learning, such as challenging behaviour and deficits in 'learning to learn' skills can occur across a range of individuals with special educational needs regardless of age. The current study evaluated the effects of an ABA intervention designed to reduce barriers to learning for children between the ages of 4- and 13-years-old. The study considered the effects of interventions for children across a wide age range, whilst extending the research base into the effectiveness of ABA interventions implemented within a special needs school setting.

Columbus School and College

The study was conducted at Columbus School and College, an academy day school with approximately 232 pupils between the ages of 3- and 19-years-old enrolled. The pupils present with a wide range of physical disabilities, developmental disorders, and learning difficulties. An ABA intervention was implemented in three classes; an early years and key stage one (KS1) class, a key stage two (KS2) class, and key stage three (KS3) class.

The Model

Behaviour Analysts collaborated with school staff to provided evidence-based educational provision and behaviour support for pupils with ASD and other disorders, disabilities, and learning difficulties. Columbus School and College utilises a broad and varied curriculum to provide access to subjects and learning experiences from the National Curriculum. In classes which delivered ABA intervention, a Board Certified Behaviour Analyst

(Behavior Analyst Certification Board, 2017) and a master's level behaviour analyst conducted assessments, developed function-based behaviour support plans, and set individual programme targets. Behaviour analysts worked with class teachers and teaching assistants to deliver these intervention programmes and provide on-going training and support.

Method

Design

A pre-test/post-test within group design was employed; initial (time 1) assessments were compared with assessments following one year of intervention (time 2) using paired samples t-tests.

Participants

Sixteen pupils from three classes participated (Table 1). All pupils had a diagnosis of ASD, a comorbid learning disability, and 86% had additional diagnoses, including attention deficit hyperactivity disorder, sensory processing disorder, or global developmental delay.

Table 1

Participant data

Class	N	Gender	Mean age	Range
Early years & key stage 1	5	5 males	65.4 months	53-82 months
Key stage 2	6	1 female, 5 males	108.6 months	100-127 months
Key stage 3	5	3 females, 2 males	151.2 months	139-162 months

Measures

The Early Years Foundation Stage (EYFS) Framework (Department for Education, 2012, 2013) was used to assess pupils under 5-years-old. Assessments were completed by class teachers using observation. Areas of learning assessed included communication and language, physical development (P.D), personal, social, and emotional development (PSED), literacy, mathematics, understanding the world, and expressive arts and design.

Teachers assessed older children using the Performance- P Scale- attainment targets for pupils with special educational needs (P-Scales: Department for Education, July 2014). P-Scales were designed to assess pupils aged 5-14 who have special educational needs and whose abilities do not yet reach level 1 of the national curriculum. The school use the BSquared (BSquared, 2015) software programme to track incremental learning and give an output in percentage of mastered EYFS level or P-scales. Pre-and post-intervention scores were analysed and predicted scores were compared with achieved scores. For the purposes of this study, the following subject domains were analysed: English, mathematics, science, personal, social, health, and emotional development (PSHE), and self-help. For analysis, similar EYFS subjects were grouped with similar P-scale subjects. The EYFS subject P.D which includes moving and handling and self-help became grouped with P-scale subject self-help, EYFS subject PSED was grouped with P-scale subject PSHE and EYFS subject understanding the world which includes science was grouped with P-scale subject science. To derive a smaller set of scores for analysis, subject domains were grouped into a small group of meta-domains: reading, writing, speaking, and listening were all grouped as English and number; shape, space and measures, using and applying, measurement, and geometry as mathematics, and the same for science. To calculate meta-domain totals, domains were summed and divided by the total number of domains within that meta-domain.

The Assessment of Basic Language and Learning Skills-Revised (ABLLS-R: Partington, 2006) was used as an assessment and curriculum guide to establish, track and address structured targets for all pupils. This assessment is specifically designed to look at basic language skills and foundation learning skills of children with ASD and other developmental disabilities. The ABLLS-R includes 544 skills from 25 skill areas including language, visual performance, imitation, self-help, academic, and motor skills. The task items within each skill area are arranged from simpler to more complex tasks. For the purposes of analysis, the 25 skill areas were divided into meta-domains: learning skills, language, social and play skills, self-help, academic, and motor skills (Grindle et al., 2012). Emerging research has shown the ABLLS-R has high validity and yields reliable scores (Partington, Bailey, and Partington, 2016; Usry, 2015). In addition, Malkin, Dixon, Speelman, & Luke, (2016) demonstrated convergent validity scores obtained from the ABLLS-R correlated strongly with those from the Vineland Adaptive Behaviour Scale (VABS: Sparrow, Balla, & Cicchetti, 2005).

The Vineland Adaptive Behavior Scale – Survey (Sparrow, Balla, & Cicchetti, 2005) was used to assess pupil's adaptive skills in the early years and KS1 class as well as the KS2 class. Assessments for the KS3 class were not conducted. The VABS entailed semi-structured interviews which were conducted face-to-face with class teachers and parents. The VABS is a standardized, norm-referenced assessment tool which measures skills across five domains: communication, daily living skills, socialisation, motor skills, and maladaptive behaviour. Overall adaptive behaviour composite standard scores are generated, as well as standard scores and age equivalents for communication, daily living skills, socialisation, and motor skills (motor skills are only generated for individuals under the age of seven).

The Behaviour Problems Inventory- Short Form for individuals with intellectual disabilities (BPI-S: Rojahn et al., 2012) was implemented with all pupils to measure challenging behaviour. The BPI-S is a respondent based behaviour rating assessment used to measure challenging behaviour exhibited by individuals with intellectual disabilities. The BPI-S measures self-injurious behaviour, aggressive and destructive behaviour, as well as stereotyped behaviour.

The ABLLS-R, EYFS Assessments and P-Scale Assessments were completed prior to intervention and again after one academic year of intervention. The BPI-S and VABS were conducted prior to intervention and again after approximately 12 months of intervention.

Procedure

Individual programmes. Behaviour Analysts developed individual education programmes based on the outcomes of the initial assessments. The ABLLS-R (Partington, 2006) was used to derive curricula goals. Individual programmes focused on communication and the development of 'learning to learn' skills such as attention, cooperation, imitation, visual performance, listening skills, self-help, independence, play, and social skills.

Teaching Strategies. Teaching strategies were based on ABA, and included reinforcement, prompting and error correction, discrete trial teaching, natural environment teaching, shaping, task analysis, and function-based behaviour plans. These strategies were described in detail in Foran et al. (2015).

Model Delivery. Trained school staff delivered all teaching and behaviour support, the staff: student ratio was 0.8:1 in the KS1 class and 0.6:1 in the KS2 class and KS3 class. The pupils attended school for 30 hours per week and received an average of five hours of 1:1 discrete trial teaching (DTT) per week in the classroom. Trained teachers and assistants conducted 1:1 teaching sessions daily. Outside of 1:1 teaching hours, pupils were supported using the principles of ABA: trained teachers and assistants implemented behaviour support plans, ran functional communication programmes which taught pupils to request for desired items and activities, and promoted the generalisation of skills learnt within 1:1 teaching sessions. The classrooms were structured and organised like all classrooms within the school. School staff organised and managed the classroom.

Staff Training. The behaviour analysts provided school staff with training and supervision in ABA interventions. Staff had no prior experience implementing ABA interventions, therefore a series of theoretical and practical training sessions were provided. Theory training was delivered in a lecture style format with opportunities for discussions and videos used to demonstrate specific teaching and learning strategies. Practical training was then delivered on-site within the classroom, with the behaviour analyst first explaining and then modelling specific strategies and the implementation of programmes. Teaching staff had the opportunity to practice engaging in the specific programmes with the pupils whilst being observed and coached by the behaviour analyst. Once practical training was complete, follow up sessions were conducted each month to monitor staff and provide further training on specific strategies.

Supervision and Consultation. As well as providing staff training, the behaviour analysts also monitored pupils progress and updated individual teaching targets and behaviour support plans throughout the academic year. A behaviour analyst was on-site in each class once per week and each pupil received an average of one hour per week of input from the behaviour analyst. The behavior analyst was able to provide feedback to classroom staff during these weekly visits.

Procedural integrity. Procedural integrity checks were employed to ensure the correct implementation of teaching strategies. Behaviour analysts observed staff and utilised a checklist to assess correct implementation of each component of a strategy; for instance, each component of discrete trial teaching was assessed (e.g. attention, discriminative stimulus, prompt, prompt fading, error correction, reinforcement, teaching pace, etc.). Procedural integrity checks were conducted during a small number of 1:1 discrete trial teaching sessions across the academic year; checks were conducted after two months of intervention and again after ten months. Procedural integrity was calculated by dividing the number of correct steps implemented by the total number of steps completed. Procedural integrity was 81.8% across all observed sessions after two months and 90.9% after ten months (Table 2).

Procedural integrity checks were also conducted on group instruction sessions by an observer independent of the study. Whilst staff knew they were being observed they were blind to all checks and measures conducted. Checks were carried out on learning opportunities and requesting. An observer measured the total number of learning opportunities within a specified interval and measured whether learning opportunities were correctly followed through, were missed or not followed through. Procedural integrity for successful learning opportunities was 91% across all observed sessions. For requesting the observer recorded each request made by pupils and how many were correctly responded to by staff. Procedural integrity for responding to requests was 100% across all observed sessions (Table 2).

Table 2

Mean procedural integrity item scores

Procedural Integrity Item	Percentage
1:1 discrete trial teaching sessions after two months	81.8%
1:1 discrete trial teaching sessions after ten months	90.9%
Successful learning opportunities	91%
Correctly responding to requests	100%

Social validity. A social validity assessment was conducted by administering questionnaires to class teachers and teaching assistants. Questionnaires were completed anonymously by 14 respondents. The questionnaire asked respondents to evaluate interventions by rating items on a scale of 1 to 5 (1 = strongly disagree and 5 = strongly agree). Respondents reported that sufficient staff training on strategies outlined in behaviour support plans and individual education programmes was provided (mean: 4.5, SD= 0.065). They reported they were comfortable implementing 1:1 teaching and learning sessions (mean: 4.5, SD= 0.065). Most respondents did not agree that ABA placed pressure on classroom staff (mean: 2.64, SD= 1.081). All respondents agreed pupils were properly assessed and their lessons were based on adequate planning (mean: 4.85, SD= 0.363), that pupils were regularly monitored (mean: 4.78, SD= 0.425), and targets were adjusted when required (mean: 4.64, SD= 0.497). They agreed programmes were trying to teach skills that all pupils needed to learn (mean: 4.5, SD= 0.650) and the focus of the programmes was on increasing positive behaviour (mean rating: 4.5, SD= 0.518). Finally, all respondents strongly agreed that pupils benefited from ABA interventions (mean rating: 5, SD= 0.0).

Results

Changes in mean scores between time one and time two data were analysed using paired samples t-tests for curriculum measures. Cohen's d formulations and conventions were used to calculate and interpret effect size. For analysis purposes, all key stages were grouped for initial analysis and post-hoc tests were conducted to determine if there were significant differences between key stages.

Curriculum Measures

Statistically significant gains were observed for changes in total ABLLS-R Scores (t (15) = -7.566, $p < 0.001$). Paired sample t-tests demonstrated statistically significant gains in learning skills (t (15) = -9.314, $p < 0.001$), language (t (15) = -4.658, $p < 0.001$), social and play (t (15) = -11.477, $p < 0.001$), self-help (t (15) = -7.125, $p < 0.001$), and motor skills (t (15) = -10.080, $p < 0.001$). Cohen's d values indicated large effect sizes for total ABLLS-R score as well as learning, language, social and play, self-help, and motor skills. Pupils made small gains in academic skills, however, this change was not statistically significant (t (15) = -1.814, p= 0.090), Cohen's d value indicated a small effect size (Table 3).

Table 3

Mean ABLLS-R group scores after one year of intervention

Measure	N	**Time 1** M (SD)	**Time 2** M (SD)	p	Effect size
ABLLS-R Learning skills	16	9.48 (10.34)	32.53 (18.72)	.000	1.52
ABLLS-R Language	16	2.94 (3.79)	12.83 (11.97)	.000	1.11
ABLLS-R Social & Play	16	3.72 (3.99)	18.71 (6.22)	.000	2.87
ABLLS-R Academic	16	3.27 (7.48)	5.95 (13.19)	.090	0.25
ABLLS-R Self-help	16	18.38 (15.51)	35.49 (23.86)	.000	0.85
ABLLS-R Motor	16	31.56 (16.37)	54.41 (18.43)	.000	1.31
ABLLS-R Total	16	6.83 (5.83)	19.99 (12.45)	.000	1.35

Gains were observed across key stages for each for each skill area assessed on the ABLLS-R, post-hoc tests revealed that differences between groups were not statistically significant. These preliminary data demonstrate that pupils across all keys stages made comprehensive progress.

Statistically significant gains were observed in EYFS and P-scale scores for English (t (15) =-5.488, p < 0.001), maths (t (15) = -3.872, p < 0.005), science (t (15) = -3.378, p < 0.005), and PSHE (t (15) = -5.056, p < 0.001). Gains were observed in self-help; however, they were not found to be statistically significant (t (15) = -52.676, p = 0.017). Cohen's d values for maths and science indicate small effect sizes, values for english, PSHE and self-help were lower than Cohen's definition for small effect size (Table 4). However, pupils exceeded their predicted EYFS and P-Scale scores for all subjects with statistically significant differences in english (t (15) = -4.625, p = < 0.001), math's (t (15) = -3.468, p = < 0.005), and PSHE (t (15) = -3.851, p = < 0.005). Gains were observed in science and self-help; however, they were not found to be of statistical significance; science (t (15) = -3.064, p = 0.008) and self-help (t (15) = -2.217, p = 0.042). Cohen's d values for maths and science suggest a small effect size, values for english, PSHE and self-help were lower than Cohen's definition for small effect size (Table 5). Differences between age groups were not statistically significant.

Table 4

Mean EYFS and P-Scale scores after one year of intervention

Measure	N	**Time 1** M (SD)	**Time 2** M (SD)	p	Effect size
EYFS & P-scale English	16	956.38 (425.59)	1015.15 (452.15)	.000	0.134
EYFS & P-scale Maths	16	1001.29 (429.95)	1112.85 (450.68)	.002	0.253
EYFS & P-scale Science	16	853.69 (389.48)	984.15 (422.67)	.004	0.321
EYFS & P-scale PSHE	16	964.06 (436.96)	1008.56 (454.13)	.000	0.124
EYFS & P-scale Self-help	16	1094.94 (454.13)	1161.19 (454.30)	.017	0.146

Table 5

Mean Predicted and Achieved EYFS and P-Scale scores

Measure	N	**Predicted Score** M (SD)	**Achieved Score** M (SD)	p	Effect size
EYFS & P-scale English	16	968.23 (426.38)	1015.15 (452.15)	.000	0.107
EYFS & P-scale Maths	16	1013.16 (430.72)	1112.85(450.68)	.003	0.226
EYFS & P-scale Science	16	865.57 (390.60)	984.15 (422.67)	.008	0.291
EYFS & P-scale PSHE	16	975.94 (437.93)	1008.56 (454.58)	.002	0.066
EYFS & P-scale Self-help	16	1105.94 (454.72)	1161.19 (454.30)	.042	0.122

Interview Measures

Statistically significant gains were observed in VABS adaptive behaviour composite scores; parent (t (10) = -4.910, p < 0.005), teacher (t (10) = -10.753, p < 0.001). Pupils made gains in communication; teacher scores were statically significant (t (10) = -5.983, p < 0.001), however parent scores were not significant (t (10) = -2.870, p= 0.017). Statistically significant gains were made with daily living skills; parent (t (10) = --5.196, p < 0.001), teacher (t (10) = -3.869, p < 0.005), and socialisation; parent (t (10) = -4.489, p < 0.005), teacher (t (10) = -6.893, p < 0.001). Cohen's d values denoted a medium effect size for parent report of communication and a large effect size for teacher report of communication. Large effect sizes for daily living skills, socialisation, and adaptive behaviour composite scores from both parent and teacher assessments were also indicated (Table 6).

Table 6

Mean Vineland Adaptive Behavior Scale (VABS) group scores after one year of intervention

Measure	N	**Time 1** M (SD)	**Time 2** M (SD)	P	Effect size
Parent VABS Communication	11	45.27 (7.02)	51.00 (7.56)	.017	0.78
Parent VABS Daily living	11	47.45 (7.17)	60.09 (7.66)	.000	1.70
Parent VABS Socialisation	11	49.54 (4.20)	57.09 (8.17)	.001	1.16
Parent VABS Composite	11	47.73 (5.57)	55.73 (6.36)	.001	1.34
Teacher VABS Communication	11	42.63 (6.62)	52.73 (5.53)	.000	1.66
Teacher VABS Daily living	11	47.18 (6.39)	54.82 (7.95)	.003	1.06
Teacher VABS Socialisation	11	46.36 (3.56)	53.18 (6.34)	.000	1.33
Teacher VABS Composite	11	45.27 (4.80)	53.64 (5.46)	.000	1.62

A statistically significant reduction in BPI-S composite scores (t (15) = -3.377, $p < 0.005$) was observed, with statically significant reductions in self-injurious behaviour (t (15) = -4.058, $p < 0.005$) and stereotyped behaviour (t (15) = -11.949, $p < 0.001$). Aggressive and destructive behaviour reductions were also observed but were not found to be statistically significant (t (15) = -1.900, $p = 0.077$). Cohen's d values indicated a large effect size for stereotyped behaviour, medium effect sizes for composite scores and self-injurious behaviour scores, and a small effect size for aggressive and destructive behaviour (Table 7).

Table 7

Mean Behaviour Problem Inventory-S (BPI-S) group scores after one year of intervention

Measure	N	**Time 1** M (SD)	**Time 2** M (SD)	p	Effect size
BPI-S Self-injurious	16	32.75 (37.38)	15.69 (25.65)	.001	-0.532
BPI-S Aggressive/destructive	16	67.25 (130.79)	33.00 (58.89)	.077	-0.338
BPI-S Stereotyped	16	46.75 (12.05)	26.06 (8.54)	.000	-1.981
BPI-S Composite score	16	146.75 (170.81)	74.75 (87.03)	.004	-0.531

Discussion

Children ages 4-to 13-years old with ASD made significant gains on measures of language, social skills, academic curriculum, and adaptive behaviours after one year of an education based on the principles of ABA. This study has provided a unique presentation of how ABA interventions can be implemented across key stages within an academy SEN school in South East England. The model is effective at improving language and learning skills, as well as adaptive behaviour in children and young people with ASD and learning difficulties. Pupils engaged in fewer behaviours of concern and developed language and learning skills which mean they can more effectively learn new skills from the classroom and wider environment.

Positive outcomes were revealed with statistically significant gains and large effect sizes demonstrated on the ABLLS-R, specifically in the areas of learning, language, social and play, self-help, and motor skills. For all pupils, gains in essential 'learning to learn skills', such as attention, imitation, basic instruction following, and basic communication were observed. Academic scores on the ABLLS-R were lower than other scores as academics were only targeted once some essential 'learning to learn' skills and basic self-help skills were acquired. Previous research has shown that children show more academic gains in the second year of intervention (Grindle et al., 2012). Some academic gains along with gains in self-help were demonstrated on school-based assessments. Statistically significant gains were observed in EYFS and P-Scale scores for english, maths, science, and PSHE. All predicted EYFS and P-scale scores were exceeded; results demonstrated statistically significant gains in achieved scores when compared to predicted scores.

It is encouraging to see results across the age ranges with every pupil making progress regardless of age. The hope is this study helps widen the scope and focus for future research with older children and adolescents and demonstrates addressing a more comprehensive range of skills including those essential 'learning to learn' skills for older children and adolescents is valuable. Significant differences between the key stage groups were not found, suggesting that children at all ages benefited equally. While previous research has demonstrated that young learners benefit from this kind of instruction, the current study found gains in students ages 4- to 13-years-old. The intervention in the current study only lasted 9 months and emphasised reducing barriers to learning. Many evaluations of EIBI consider data from across 2 years of intervention. Future research should consider if older children will continue to benefit from an education based on the principles of ABA over several years.

It is recognised the ABLLS- R and EYFS and P-Scale assessments are not standardised assessment tools, however the ABLLS-R is a useful tool for baselining skills and programming and EYFS and P-Scale assessments are often used as standard practice within SEN settings. Both these assessments have shown the children made significant skill gains over the course of the intervention. The Vineland Adaptive Behaviour-Scale (Sparrow et al., 2005) is a standardised assessment tool and outcomes demonstrated on this measure are especially promising with statistically significant and large effect sizes being demonstrated for composite scores from assessments with both parents and teachers. The results suggested pupils surpassed normative expectations of progress. In addition, parents reporting above expected gains not only verifies gains reported by teachers, but also suggests pupils were generalising skills they had learnt at school into their home environment.

Statistically significant reductions were observed in BPI-S composite scores specifically in self-injurious behaviour and stereotyped behaviour scores, suggesting function-based behaviour support plans were effective in reducing challenging behaviour. Pupils learnt more appropriate replacement behaviours and were more able to functionally get their needs met. They were engaging in fewer harmful behaviours and more able to engage in learning activities and learn from the classroom environment.

The results are similar to those from a study into outcomes for pupils receiving intervention within a specialised ABA school, in which pupils aged six to eighteen demonstrated gains on ABLLS-R and VABS (Lambert-Lee et al., 2015). However, the conditions described in the present paper are substantially different from the conditions in which the ABA school study and EIBI studies took place; the pupils did not receive 1:1 support throughout the day instead they received 1:1 teaching for approximately one hour per day and for the remainder of day were supported in ratios of 0.8:1 or 0.6:1. Interventions were not delivered by ABA tutors who are typically degree level educated, the model did not include ABA supervisors, and not all staff within school were ABA trained. Moreover, parental involvement was somewhat limited, whilst involvement was encouraged and targets and progress were shared, home visits, and specific home based support was not provided. Despite these differences, the pupils in this study made large gains on ABLLS-R and on VABS composite scores, particularly in communication and daily living skills.

The study is not without its limitations; it has a relatively small sample size and did not include a comparison or control group. Despite this, post-intervention gains were positive and additional research is currently being planned and conducted. In addition, this study has relative strengths; a range of measures were used to demonstrate progress and procedural integrity and social validity measures were utilised with social validity found to be high with all staff agreeing all interventions benefitted pupils.

The study has outlined how a behavioural model was practically and productively employed within a special educational needs school. The affordability of the model including training teachers and teaching assistants to deliver intervention may mean it’s more accessible and more feasible for other SEN schools to adopt. Further research is required into the use of the model described, but ultimately identifying an effective and affordable model of intervention for pupils within these age ranges may lead to more pupils accessing and benefiting from more successful interventions within SEN settings.

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Chapter 5

~ Mastery Criteria and the Maintenance of Skills in Children with Developmental Disabilities[3] ~

Chapter 5 investigates the under-researched area of mastery criteria and the maintenance of skills in children with developmental disabilities.

[3] This chapter is under review as 'Mastery Criteria and the Maintenance of Skills in Children with Developmental Disabilities', by Pitts, L., & Hoerger, M. L.

Abstract

Behaviour analysts typically set a criterion for correct responding to determine when a skill is considered mastered. Practitioners often pre-set the criteria arbitrarily as there is little empirical evidence about the effects of differing mastery criteria on the maintenance of skills. The aim of the current study was to evaluate the effects of differing mastery criteria on skill maintenance. The impact of 80%, 90%, and 100% correct responding on the maintenance of sets of skills taught during discrete trial teaching was evaluated. Four children aged between 5- and 9- years-old with a diagnosis of Autism Spectrum Disorder participated in the research. Sets of skills were taught until each of the three criteria were met, skill maintenance was probed after one week and again once per week for another three weeks. Results demonstrated that mastery criteria of 100% reliably produced higher levels of maintenance than a mastery criteria of 80% and 90%.

Educational programmes based on applied behaviour analysis (ABA) for children with developmental disabilities and learning difficulties typically employ a range of teaching methods including discrete trial teaching (DTT) and natural environment teaching. In DTT teachers repeatedly present a stimulus, instruction, and prompt, and then reinforce correct responding until the child responds correctly and independently for a pre-determined number or percentage of trials, often referred to as mastery criteria.

Mastery criteria are typically pre-set by the teacher or practitioner. Standards for mastery criteria vary across the literature and much of the existing evidence for the effects of differing mastery criteria involve evaluations which have been conducted with neuro-typical college students (Carlson & Minke, 1975; Fienup & Broadsky, 2017; Johnston & O'Neil, 1973; Keller, 1968; Semb, 1974). With limited empirical evidence, many practitioners have made recommendations for setting mastery criteria for individuals with developmental disabilities or learning difficulties based on clinical judgment and experience. Granpeesheh, Tarbox, Najdowski and Kornack (2014) recommend setting mastery criteria for individuals with Autism Spectrum Disorder (ASD) at 80% to 100% correct for two or three consecutive sessions. Leaf and McEachin (1999) recommend a general criterion for correct responding of 80 to 90% correct over two to three days with at least two different teachers, however they suggest the criterion should be adapted to accommodate the individualised needs of learners.

Clinical practices regarding mastery criteria differ widely. Love, Carr, Almason, and Ingebor Petursdottir (2009) conducted a survey of clinical practices including mastery criteria practices with professional supervisors of early intensive behavioural intervention programmes; 62% (n= 119) of respondents reported using a percentage of correct trials across multiple sessions (e.g. 80% correct across two or three sessions), and 61% (n= 118) reported using a specific percentage of correct trials across two or more therapists (e.g. 80% correct across two or three sessions and at least two or more therapists).

Richling, Williams, and Carr (2019) conducted a survey of clinical practices related to mastery criteria practices with 194 board certified behaviour analysts and doctoral level board certified behaviour analysts. A majority (68%) of respondents reported using a specific percentage of correct trials. A further 28% of respondents set mastery criteria as a specific number of correct trials in a row, with a small minority (4%) using a rate of unit per time (fluency). The most frequently used mastery criterion was reported to be 80% accuracy over one or more consecutive sessions. Whilst these studies provide an indication of what is commonly used, empirically validated evidence on what is effective is scarce. Little is known about the effects of differing mastery criteria on response maintenance. Response maintenance refers to the extent to which an individual is able to perform a skill after teaching is reduced or terminated. The number of successful, reinforced learning opportunities prior to the termination of teaching a skill is likely to effect response maintenance. A high number of successful learning opportunities leads to more frequent contact with positive reinforcement, which may strengthen behaviour and result in behaviour which is maintained more effectively. Thus, it would be reasonable to hypothesise higher mastery criteria would result in strengthened behaviour, and behaviour which ultimately maintains more effectively over time.

To our knowledge, only a few studies have been conducted to determine the effects of mastery criteria on response maintenance with children with ASD. Fuller and Fienup (2017) evaluated the effects of three different mastery criteria on response maintenance. Three children aged between 5- and 7- years-old with a diagnosis of ASD participated in the research. Literacy skills were taught until the children met different mastery criteria (50%, 80%, and 90%). Skill maintenance was evaluated once per week for three to four weeks. Results indicated the mastery criterion of 90% led to higher levels of maintenance responding.

Richling et al. (2019) conducted an experimental evaluation of different mastery criteria with four children aged between 6- and 9- years old with developmental disabilities. In two experiments discrimination tasks and vocal tacting were taught to 60%, 80%, and 100% mastery criteria. Maintenance probes were conducted weekly for four weeks after the participant achieved the mastery criteria. The highest levels of maintenance were observed when skills were taught to 100% mastery criteria for three sessions. In a further experiment, vocal tacting tasks were taught to 80%, 90%, and 100% mastery criteria and response maintenance probes conducted following one week of criteria being met. Results revealed skills taught to 100% mastery criteria were maintained at the highest rate. The skills taught to 80% did not maintain effectively, suggesting 80% mastery criteria may not be enough to promote the maintenance of skills in some children.

The current research evidence suggests higher mastery criteria result in skills which maintain more effectively over time. The research is limited to a small number of studies, which have looked at a limited number of skills and delays to maintenance probes. The current study seeks to replicate and extend these findings, which could influence how practitioners allocate teaching time to emerging skills. The differences between setting the mastery criteria at 80%, 90% or 100% could have significant implications in terms of teaching time and skill acquisition rates. If the lower mastery criteria of 80% can establish mastery, and skills are demonstrated to maintain over time, then the overall time spent teaching may be lower and more skills can be taught in the same period of time. However, if lower criteria mean skills do not maintain effectively then time could be lost re-teaching the skills later.

In a partial replication of the study by Richling et al. (2019) the current research compared the effects of three mastery criteria: 80, 90%, and 100% on response maintenance. Three sets of stimuli within the same response class were taught to four children with ASD to evaluate the effects of the different mastery criteria on response maintenance. The stimuli sets were taught until responding met the pre-determined mastery criteria, and response maintenance probe sessions began one week later. Maintenance probes were conducted once per week for four weeks.

Method

Participants and Setting

Four children participated in this experiment. All of the participants had a diagnosis of ASD and a comorbid learning difficulty, two had an additional diagnosis of global developmental delay and sensory processing disorder. Inclusion criteria to be invited to participate in the research were for students to have basic receptive language skills, including being able to receptively identify items and pictures by touching, pointing or gesturing with their hand.

Ruby was a 7-year-old female and Theo was a 5-year-old male; both could follow simple instructions and communicate using words and short sentences to mand, tact and respond to intraverbals. Participant two had some low-level behaviour of concern (e.g. looking away, pushing task stimuli away with hands, throwing items with hands, and vocal protesting) related to escape from demand and attention. Noah was a 6-year-old male who was able to follow simple instructions and communicate using a Picture Exchange Communication System to mand and comment. He engaged in vocal protesting and hitting with his hands to access tangible items. Isla was a 9-year-old female who was able to follow simple instructions and communicate using a combination of sign language and vocals; she could use signs and words to mand, tact and respond to intraverbals.

The participants attended either a special educational needs school or a mainstream school where they received an education based on ABA. All participants were familiar with discrete trial teaching strategies. Each session was conducted in a teaching room familiar to the participant. An ABA trained practitioner who was known to the participant conducted the sessions. The practitioner sat next to or opposite the participant during all sessions. An observer was present for some sessions for interobserver agreement and procedural integrity check purposes. Sessions were conducted 1 to 3 times per day for 3-4 days per week based on participants and practitioners availability.

Materials

Materials included tokens and token boards with space to attach 5 tokens; word cards (10.5cm by 14.8cm) on which words were printed in black text on a white background; data sheets; preferred edibles, preferred toys and items; an electronic timer to time access to preferred toys and items.

Response Definitions and Measurement

Data were collected on participant responses during each discrete trial. Ten trials per session were run and the percentage of trials during which the participant responded correctly calculated. Correct responses were defined as the participant independently touching or pointing to the correct stimuli. Prompted responses were defined as trials during which prompts were provided to assist a correct response. Incorrect responses were defined as responses which did not correspond with the target stimuli or the participant not initiating a response within five seconds of the instruction being given.

Interobserver Agreement and Procedural Integrity

Interobserver agreement (IOA) was calculated by dividing the number of trials in which both observers agreed by recording the same correct responses in a session by the total number of trials and multiplying by 100. IOA was collected for 31.48% of baseline sessions, 37.80% of intervention sessions, and 30.13% of maintenance probe sessions. IOA was 99.36% for baseline sessions, 96.34% for intervention sessions, and 94.33% for maintenance probe sessions.

Procedural integrity checks were employed to ensure baseline, intervention, and maintenance probe sessions were implemented as designed. Observations of sessions were conducted and checklists were used to assess the correct implementation of procedures. Procedural integrity was collected on 26.67% of baseline sessions, 28.29% of intervention sessions, and on 25% of maintenance probe sessions. Procedural integrity was found to be 94.14% for baseline sessions, 96.87% for intervention sessions, and 97.22% for maintenance probe sessions.

Target selection

Baseline sessions were preceded by target selection sessions. Targets consisted of written words which were selected if they were unfamiliar to the participant. A pool of potential target words were created with assistance from the participants teaching team. Probe sessions were conducted to ensure the proposed skills were unknown to the participants. During probe sessions, the teacher presented the written word in an array of 3 and gave the instruction "Touch… (target word)". There were no programmed consequences for participants responses during probe sessions. For each participant, nine unknown written words were split into three sets of three. Word length and the number of syllables per word were counterbalanced across sets, so words containing a similar number of letters and syllables were equally distributed to each criteria. One word from each set of three target words was taught until the participant responded independently and correctly to either 80%, 90%, or 100% mastery criteria. Researchers ensured the target words were not included as teaching targets in participants regular education plan for the duration of the study.

Design

A combined alternating treatment design and multiple-baseline design across participants was employed to evaluate skill maintenance following the teaching of sets of words to three mastery criteria; 80%, 90%, and 100%.

Procedure

Baseline. Baseline sessions mirrored the target selection trials. Ten trials were run during each baseline session. There were no programmed consequences for participants' responses to the target stimuli during the baseline sessions.

Intervention. Paired choice preference assessments were conducted at the start of each session to identify potential reinforcers to be used during teaching sessions. At the beginning of each teaching trial, the participant was presented with three cards which included the target word and two unknown distractors. The teachers said "Touch… (target word)". Least-to-most prompting procedures were used to facilitate learning. Least intrusive prompts were implemented initially, and prompts gradually increased as necessary: 1) Gestural (e.g. point prompts, hand gestures, nods of the head; 2) Positional (e.g. moving the target item closer to the participant); 3) Model (e.g. demonstration of the task); 4) Partial physical (e.g. gentle tap of the hand or arm); 5) Verbal prompt (e.g. repeating instructions, giving clues, explanations, verbal encouragement); 6) Full physical (e.g. hand over hand prompting).

Reinforcement in the form of a token was delivered following an accurate response on a fixed ratio 1 (FR1) schedule of reinforcement. Social praise (e.g. “well done”, “nice work”) was paired with the delivery of the token. The tokens were placed on a board, once five tokens were earned the participant exchanged them for a back-up reinforcer (e.g. a preferred edible, or one minute of access to a preferred toy, item or activity). Following an incorrect response, the teacher quickly provided feedback such as “not quite’ or “try again”, reissued the instruction, and immediately prompted the correct response using the least intrusive appropriate prompt. The instruction was repeated to give the participant the opportunity to respond independently. Ten trials were run in each intervention session.

Mastery Criteria. The teaching sessions were terminated once the pre-determined mastery were met criteria for three consecutive sessions. In the 80% and 90% conditions the first trial of each session was required to be correct; as if the initial trials were always prompted and subsequent trials were correct this wouldn’t necessarily indicate true skill acquisition, and could have over inflated progress.

Maintenance Probes. Maintenance probe sessions were conducted once per week for four weeks after mastery criteria had been met. Ten trials per session were run. Maintenance probe sessions were identical to baseline sessions, with the exception that reinforcement was given following a correct response.

Results

Figure 1 displays the session data. Throughout baseline sessions each participant's correct responses were relatively low. In the acquisition phase the participants' accurate responding increased until mastery criteria were achieved or exceeded. During the maintenance phase Ruby demonstrated mean responding of 77.5% (range 70%-90%) for skills taught to 80% mastery criteria, 95% (range 90%-100%) for skills taught to 90% criteria, and 98.33% (range 90%-100%) for skills taught to 100% criteria. For Theo a more distinct difference between mastery criteria and maintenance responding was observed; 76.66% (range 60%-90%) for skills taught to 80% mastery criteria, 87.5% (range 80%-100%) for skills taught to the 90% criteria, and 98.33% (range 90%-100%) for skills taught to 100% criteria.

Noah's mean maintenance responding for skills taught to 80% mastery criteria was 76% (range 60%-90%), for skills taught to 90% criteria; 90.83% (range 80%-100%), and 96.67%, (range 90%-100%) for skills taught to 100%. Finally, Isla's mean maintenance responding was 75% (range 60%-90%) for skills taught to 80% criteria, 92% (range 80%-90%) for skills taught to 90% criteria, and 98.33% (range 90-100) skills taught to 100% criteria.

For all four participants 80% mastery criteria resulted in lower rates of accuracy during maintenance in comparison to 90% and 100% mastery criteria. For all four participants the highest level of accuracy during the maintenance phase was observed with skills taught to 100% mastery criteria. Skills taught to 90% mastery criteria maintained at slightly lower rates than the 100% mastery criteria, but still slightly higher than the 80% mastery criteria.

Analysis of the pooled results for all four participants indicated skills taught to 80% mastery criteria maintained at a mean of 76.46% (range 60-90), skills taught to 90% mastery criteria maintained at a mean of 91.46% (range 80-100), and skills taught to 100% mastery criteria maintained at a mean of 97.92% (range 90-100). These pooled results suggest 100% mastery criteria have the most significant effect on the maintenance of skills over a four-week period.

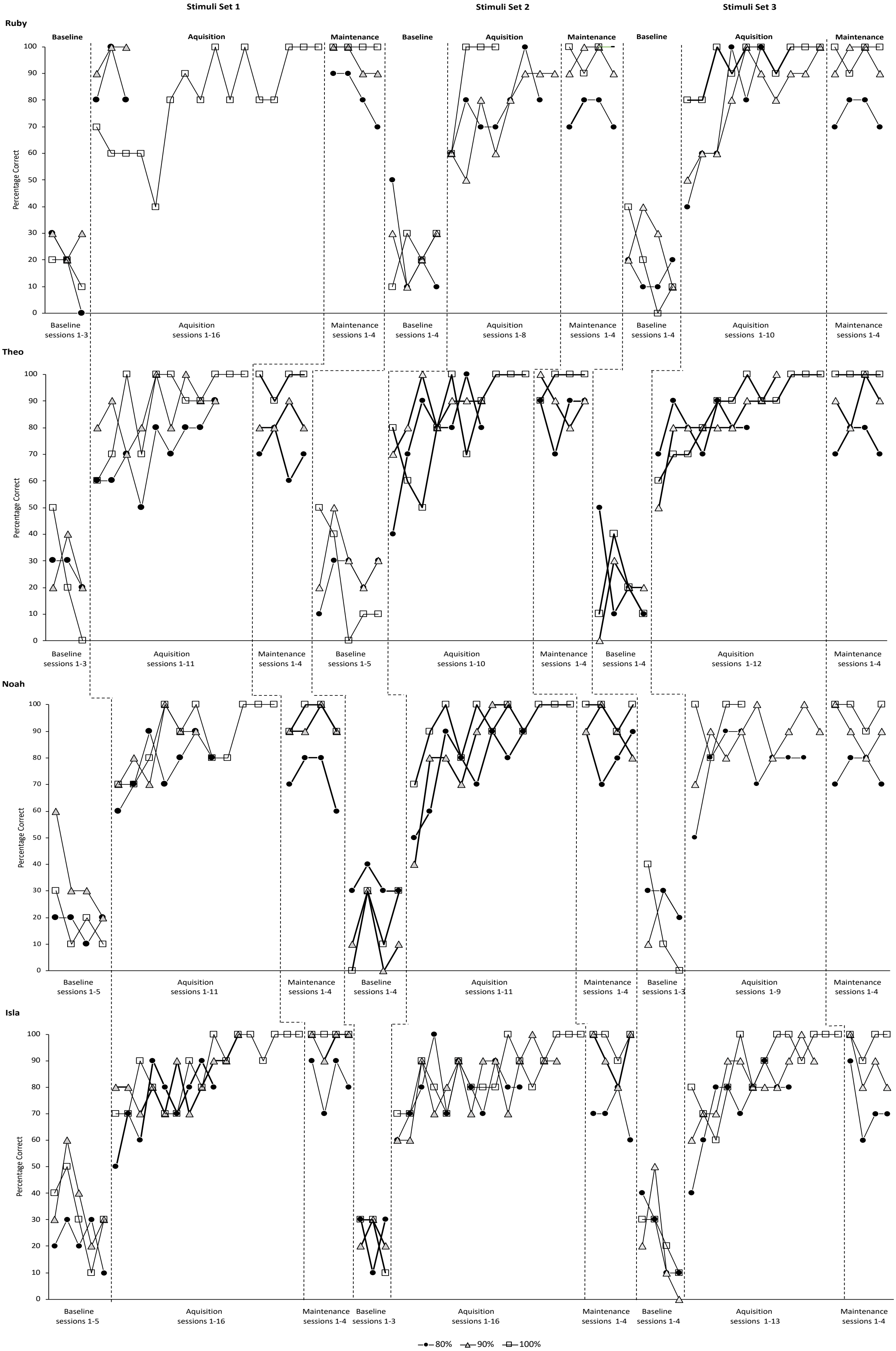

Figure 1. Percentage of correct responding during baseline, acquisition and maintenance sessions. Precisely 1 week elapsed between the final acquisition session and the first maintenance session. Subsequent maintenance sessions were conducted 1 week apart.

Discussion

The purpose of this study was to compare the effects of three different mastery criteria on skill maintenance for four children with developmental disabilities. Practitioners may sometimes choose to teach to lower mastery criteria to allow more time to teach new skills; however, it is probable that skills mastered to correct responding on 80% of opportunities may not be sufficiently mastered to be robust over time. The most commonly used mastery criteria are reported to be 80% (Richling et al. 2019), however skills taught to 80% mastery criteria have not been found to be sufficient in promoting skill maintenance in some children (Richling et al. 2019).

The findings of the current study add to an emerging evidence base suggesting higher mastery criteria results in skills which maintain more effectually. The present study evaluated maintenance with skills taught to 80%, 90%, and 100% mastery criteria. Skills taught to 100% mastery criteria resulted in the highest levels of maintenance following termination of teaching sessions, suggesting employing criteria in which 100% correct responding occurs for three sessions is more effectual for promoting the maintenance of skills. These results are in line with those of Richling et al. (2019). In the study by Richling et al. (2019) vocal tacting tasks were taught to 80%, 90%, and 100% mastery criteria and maintenance probes conducted following one week of criteria being met. The current study extended this further by conducting maintenance probes over four weeks so the effects of these criteria on response maintenance could be evaluated over a longer period of time.

In the current study pooled results for all participants suggest maintenance levels matched mastery criteria to some degree. The 80% mastery criteria resulted in skills which maintained at a mean of 76.46%, 90% criteria at a mean of 91.46%, and 100% criteria at a mean of 97.92%.

Stimuli sets taught to 100% mastery criteria condition typically required a higher number of consecutive teaching sessions to reach criteria than those in the 80% and 90% criteria conditions. Stimuli sets in the 100% mastery criteria conditions consequently had the greatest number of learning opportunities, as well as the highest number of successful trials, and contacted the most positive reinforcement, all of which is likely to have strengthened skills and resulted in skills which maintained more effectively. Both the 90% and 100% mastery criteria conditions, however, resulted in maintenance levels above 90% accuracy, so in circumstances where an individual achieves 90% mastery criteria faster or over fewer teaching sessions than in the 100% mastery criteria then 90% could be an efficient criteria.

Practitioners need to consider the type of skills being taught when setting mastery criteria. For skills related to health and safety it would be prudent to teach to 100% mastery criteria. For reading or sight word skills, such as those taught in this study it would also make sense for them to be taught to higher criteria as recalling words accurately is essential to reading. However, other measures such a fluency would also come into effect with reading and many other skills. This study did not include fluency measures, but it could be beneficial for future work to look at how both fluency and mastery criteria impact the maintenance of skills. Another point practitioners should consider when setting mastery criteria is functional or socially valid maintenance levels for the skills they are teaching. It could be useful to evaluate maintenance levels of skills in neurotypical peers and set criteria accordingly.

This study is limited by the evaluation of only one category of skills: receptive identification of words. Words were assigned to conditions based on the number of letters and syllables they contained in attempt to control for some aspects of word difficulty.

However, other aspects of word difficulty such as, number of phonemes, or diagraphs, trigraphs, or short or long vowel sounds were not accounted for specifically. Thus, in terms of difficulty there is a possibility that words could have been disproportionately allocated to their sets. However, it could be suggested that even if this were the case the impact of this was minor as results revealed fairly distinct differences in the effects of differing mastery criteria on skill maintenance. Future research should explore if and how mastery criteria affects the maintenance of other skills (such as tacting, intraverbals, visual performance tasks, etc.).

The current study evaluated accurate responding which occurred over three consecutive days. Dimensions of mastery criteria could warrant investigation, such as the number of consecutive sessions in which correct responses occur (e.g. over one session, two consecutive sessions or three consecutive sessions). Fuller and Fienup (2018) looked at correct responses which occurred only over one session. Increasing the mastery criteria over consecutive sessions at 100% correct would however, result in increased successful learning opportunities and ultimately more contact with positive reinforcement; both of which may result in more durable behaviour, and behaviour which maintains more effectively. Setting criterion at 100% is not without its problems, it has been suggested a mastery criterion of 100% can lead to frustration and boredom with a task and may be unrealistic as mistakes can be due to variables other than lack of understanding (Leaf and McEachin, 1999). It is important to account for individual differences and make adjustments based on the individual’s learning pattern.

Generalisation across different stimuli, settings, and people wasn’t programmed for in the current study but could be worth exploring. The process of generalising across stimuli, settings and people would create additional practice opportunities which could consequently increase understanding, responding, and contact with reinforcement which could all subsequently influence skill maintenance.

We have investigated three different mastery criteria and their effect on skill maintenance in a population with which there is very little research into mastery criteria to date. The focus of future work should be on evaluating the specific components of mastery criteria itself across a range of different skills and populations. Future work should also look at other variables which may or may not be working in combination with, or potentially more heavily influencing skill maintenance such as teaching strategies, generalisation procedures, and schedules of reinforcement. Whilst further investigation is required, this study adds to the preliminary evidence suggesting 80% mastery criteria may not be sufficient in maintaining skills in some children, and higher more stringent mastery criteria are more effective in maintaining skills in children with developmental disabilities.

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Chapter 6

~ Final discussion and conclusions ~

This thesis has described how a school-based model of ABA can be delivered in a UK SEN school. In chapter 3 the control group study demonstrated that young pupils who received education based on the school-based model of ABA made greater gains in cognition, language and communication, daily living skills, and socialisation than pupils who received EAU. In Chapter 4, the age comparison study the model was extended across older pupils, outcomes revealed all pupils regardless of age made significant gains in learning skills, language and communication, social and play, and self-help skills following one academic year of intervention. Chapter 2 discussed the importance of identifying and utilising effective components of skills teaching, with the final study in this thesis exploring the under-researched area of mastery criteria. The mastery criteria study explored the effects of differing mastery criteria on the maintenance of skills. This study found that commonly used 80% criteria may not be effective in maintaining skills in some children and 100% mastery criteria was more effective in maintaining skills over a four week period. The three studies and their outcomes are summarised in this chapter. The studies limitations, implications, and contributions to the field are discussed, along with recommendations for further research.

The ABA intervention model

The aim of the first two studies were to explore and evaluate the application of the ABA intervention model within the context of a UK special needs school. The ABA intervention model involved behaviour analysts and school-based staff working in collaboration to deliver ABA-based teaching and behaviour support. Pupils were supported and taught by ABA trained teachers and teaching assistants throughout the day using the principles of ABA. The ABA trained staff provided each pupil with function-based behaviour support and individual education programmes, and five hours of 1:1 teaching per week. Staff also encouraged the generalisation of skills learnt within 1:1 teaching sessions within the classroom and around school.

The first study in this collection, the control group study was the first of its kind in the UK to compare two groups of young children who received either; school-based ABA intervention (n=10) or EAU (n=10). All children were aged between 4- to 7-years of age at intake and were assessed on measures of intellectual development, adaptive functioning, and maladaptive behaviour pre-intervention and one year following intervention. Pre-test measures indicated the groups did not differ significantly at intake. After one-year, children in the group receiving intervention based on ABA made larger gains than those in the EAU group on measures of language and communication, cognitive skills, daily living skills, and socialisation. These outcomes are exciting as children made meaningful gains which enabled them to engage and learn more effectively in the classroom. It also provides preliminary evidence for the feasibility and effectiveness of the model. From a practical perspective it demonstrated teachers and teaching assistants could be effectively trained to provide ABA-based teaching and function-based behaviour support. The model was adopted using staffing ratios typical in this SEN setting, so there were no additional class-based staffing costs, only the costs of the behaviour analysts were incurred.

The results of the control group study are in line with the outcomes of previous studies which have demonstrated interventions based on ABA are more effectual than EAU in reducing barriers to learning and increasing adaptive behaviour (Eldevik, Eikeseth, Jahr, &

Smith 2006; Eikeseth, 2009; Eikeseth, Smith, Jahr, & Eldevik, 2002; Grindle et al., 2012; Petters-Scheffer, Didden, Mulders, & Korzilius, 2010, 2013).

The control group study has some methodological strengths which have reduced possible bias and increased validity. MSEL assessments which measured intellectual development and VABS post-test assessments which measured adaptive behaviour were conducted by an independent practitioner who was blind to the conditions of the study, this reduced any possible bias. Measures of procedural integrity also strengthen the study. Procedural integrity is essential for empirical evaluation of the efficacy of an intervention, as it permits for clearer interpretation of the outcomes. Ensuring procedural integrity or treatment integrity as it is otherwise known is essential in the dissemination of evidence-based practices (Perepletchikova, 2011). High social validity outcomes increase the robustness of the study further. Social validity refers to the importance and acceptability of interventions and outcomes. Within evidence-based practice and ABA specifically the prominence of valued clinical outcomes are emphasised as an important component of both research and practice (Baer, Wolf, & Risley, 1968). The high social validity outcomes of this study suggest interventions were well accepted, and possibly more likely to be adopted and maintained in future.

The study was limited by its relatively small sample size and by the fact a fully randomised control trial design was not employed. Unfortunately, it was not possible in the setting at the time to adopt a fully randomised control design. Anecdotally the school leadership team insisted on allocating pupils to the intervention group based on two main criteria, firstly, the pupil was not making progress as measured by school-based assessments and secondly, the pupil engaged in behaviours which were currently harmful and/or interfering with their ability to learn. Whilst there were some data for allocation it was not complete or consistent enough to present. The leadership team were very clear on who to allocate to the intervention group and the ethics of withholding a potentially effective intervention from the pupils who were making the least progress and engaging in the most harmful behaviours were discussed. From an ethical perspective their decisions were respected. Future research should explore larger sample sizes and the use of random assignment to groups where possible. The use of randomised assessment in school-based settings certainly poses a challenge and the ethical issues are likely to be similar across different settings. Despite the limitations of the control group study, it does provide some convincing evidence for the effectiveness of ABA intervention models which include lower hours of 1:1 teaching, but daily support using the principles of ABA, group teaching, and function-based behaviour support, especially when compared to EAU.

The second study in this thesis, the age comparison study was conducted to evaluate the effectiveness of ABA intervention model for a wider age range of pupils with ASD and additional LD's. A group design was used to evaluate the effects of ABA interventions designed to reduce barriers to learning with individuals aged 4- to 13-years of age. The study employed the model utilised in the first study. The pupils were assessed at baseline and again following one academic year of intervention using the ABLLS-R, EYFS and P-scale assessments, VABS, and BPI-S. Outcomes revealed significant gains in learning skills, language and communication, social and play, and self-help skills. All pupils regardless of age acquired essential 'learning to learn' skills which reduced their barriers to learning and enabled them to learn more effectively within school and from the environment more generally. This study is the first in the UK to demonstrate such significant findings across the age range with this kind of intervention. Prior research has demonstrated how young children benefit, but the age comparison study found gains in young children as well as older children up to 13-years of age. It is exciting to see such results across the age ranges. Significant differences between the key stage groups were not indicated, suggesting pupils of all ages profited similarly.

It's important to note both the control group study and study age comparison study only tracked progress over the course of a year for pupils who had not received any ABA-based intervention before. Further work is required to evaluate how pupils respond to a second year of intervention. Some studies have reported the largest gains from EIBI are observed in the first year of intervention, and while significant improvements continue to be observed into the second year they are not observed at the same rate as the first (Eikeseth, Klintwall, Jahr, & Karlsson, 2012; Grindle et al., 2012; Howard, Stanislaw, Green, Sparkman, & Cohen, 2014). There has been some possible explanations for this including, the focus and complexity of the programmes increasing over time (Grindle et al. 2012), as such the programmes are more challenging and time-consuming, thus targets take longer to learn. It is also possible these earlier gains are related to age and the children being a year younger in their first year of intervention, but further work is required to investigate just how much is related to age and the impact of a child being just one year younger. These greater first year outcomes have been demonstrated through EIBI applications of ABA, but the current model is a different application of ABA, thus it is uncertain whether these finding would generalise to this model. In the first instance further investigation is require to establish if and how pupils continue to respond to a second year of intervention, and if similar findings to the EIBI literature are found, then further investigation is warranted into possible reasons for this (e.g. programme complexity, age, etc.). It may also be useful to see if and how pupils who have received EIBI or ABA-based intervention in the past respond. It is possible that the findings of the age comparison study may not apply to pupils who have already received EIBI, but further investigation is required to verify or refute this.

It would be useful to evaluate and explore how the model sits during the course of a second year. It's likely the focus, targets, and outcomes of intervention would vary from the first year, as already highlighted the second year may see increases in complexity and thus slower acquisition rates. In addition, the focus of intervention is likely to change across the key stages, with pupils in key stage one perhaps transitioning onto a more academic curriculum and pupils in key stage three moving onto a more functional daily living skills curriculum aimed at developing independence. Key stage two pupils may sit somewhere in between with more of a combination of academic and functional daily living skills. Whilst all the programmes are individualised based on the outcomes of individual assessments and there are highly likely to be individual differences from pupil to pupil, it would still be useful to explore the focus on the interventions.

The results of the age comparison study are in line with that of Lambert-Lee et al. (2015) who found pupils of all ages benefitted from ABA intervention. However, the intervention used in age comparison study was much less intensive and the conditions were considerably different. The pupils in the age comparison study received 1:1 teaching for approximately one hour per day and were otherwise supported in ratios of 0.8:1 or 0.6:1. In the study by Lambert-Lee et al. (2015), pupils were supported on a 1:1 basis all day by ABA tutors who were typically degree level educated. In the age comparison study teaching was delivered by trained school-based staff, rather than ABA tutors. Irrespective of these differences, the pupils in the age comparison study made substantial gains on the ABLLS-R and in VABS composite scores, especially in communication and daily living skills.

The outcomes of the age comparison study support the findings from the meta-analysis by Roth, Gillis, & GiGennaro (2014), which demonstrated older children and adolescents benefit from ABA-based interventions. Specific improvements were observed in behaviour of concern and adaptive behaviour, both of which may lead to improvements in quality of life for individuals with ASD, as well as bring potential financial benefits. Reducing behaviour of concern and increasing adaptive behaviour ultimately increases independence and may reduce the need for intensive support in future or reduce the need for an autism specific residential school placement. Residential schools for individuals with ASD in the UK may cost as much £156,360 per year thus the potential savings could be significant. Increased independence may reduce the need for respite care, supported living, and residential care placements in future, significantly reducing the cost of adult support services (Smith, Hayward, Gale, Eikeseth, & Klintwall, 2019). Thus, the costs of delivering the ABA-intervention model may not be anywhere near as high as the potential long-term savings. Further work is necessary to explore the cost and long-term benefits of the model.

The age comparison study is limited by its pre-test/post-test within-group design; however, it was simply an initial feasibility study. As the model had not been tested across the key stages before, this study was conducted to determine whether the ABA intervention model could firstly, be practically delivered across a larger age range of pupils, and secondly, whether it would result in positive outcomes for older children and adolescents. Whilst somewhat weak in design the study was still worthwhile as it demonstrated the model could be practically extended across the key stages and result in positive pupil outcomes. The study demonstrated the intervention model can be implemented as planned and proposed across three key stages. It established the intervention can be provided when there may be school-based and key stage-based time and resources constraints. It also confirmed that intervention procedures could be adapted to be appropriate to a wider age range of pupils. With this initial feasibility test passed further research into the implementation of the model across the key stages is now required. Future research should focus on larger replications across different schools and the use of a comparison or control group.

Whilst the age comparison study had its limitations post-intervention gains across pupils were promising and the study's robustness is increased by the range of measures used to demonstrate progress, as well as measures of procedural integrity and social validity. Extending the model across key stages proved a fruitful venture which demonstrated pupils made significant progress regardless of age. This study highlights the importance of addressing a more comprehensive range of skills, including those essential 'learning to learn' skills, for older children and adolescents.

The outcomes of both the control group study and age comparison study are consistent with those of Foran et al. (2015), who found pupils who received school-based ABA intervention made significant gains in intelligence, language skills, and play and social skills. Both studies join the growing evidence base for the effectiveness of low intensity ABA interventions which deliver lower hours of direct teaching, as well as demonstrating ABA interventions can be effectively implemented within existing school settings (Foran et al., 2015; Peters-Scheffer et al., 2010, 2013; Pitts, Gent, & Hoerger, 2019). In practice when settings are unable to deliver intensive ABA intervention with high levels of direct 1:1 teaching, then interventions with lower levels of 1:1 teaching accompanied with group teaching and current school-based services can be an effective alternative (Foran et al., 2015; Pitts et al., 2019).

Whilst it is recognised that direct 1:1 teaching hours are essential in a high number of pupils with ASD developing new skills, additional elements of the ABA intervention model presented in this thesis are also likely to have contributed towards pupil progress. Individualised behaviour support for example, helped reduce harmful behaviour and increase functional skills. Training staff to support pupils using the principles of ABA across the school day also meant further learning opportunities outside of the 1:1 teaching sessions were provided, as well as further opportunities for generalisation and maintenance. On-going opportunities for generalisation is likely to be a key part of the model. Staff were trained to teach loosely (Cooper, Heron, & Heward, 2007). Thus, aspects of teaching were varied throughout the day. Teaching settings were varied meaning the number of people in the environment and stimuli within the environment naturally varied (e.g. there would have been natural variations in lighting, sounds, and temperature, etc.). Teaching staff were varied, so pupils worked with different staff members at different times of the day. The availability of reinforcers would have naturally varied to some degree depending on staff and locations. Instructions were varied as much as possible from the outset of teaching, so staff altered the way in which they spoke and the words that they used. Teaching stimuli were also varied, and multiple examples were used. Further research is required into the practice of teaching loosely to aid generalisation around the classroom and school. Essentially, future research should explore each element of the model and attempt to identify vital components.

Future research should also attend more closely at other variables which may impact pupil outcomes. It could be worthwhile to explore the link between outcomes and intervention specific variables, such as the intensity of the intervention; number of direct 1:1 teaching hours, plus duration of intervention. Further research is also required explore the link between outcomes and pupil specific variables at intake, such as age and pupil skills (e.g. IQ, language and social skills, and level of adaptive behaviour, etc.).

Together study one and two have delineated how a behavioural model was both practically and productively employed. As discussed previously there is an absence of ABA interventions being utilised within UK schools, this could be owing to a number of barriers including dissemination, training, common misconceptions, funding, acceptance, as well as a gap between the research evidence and practice. Thus, more practical and cost-effective school-based models which overcome these barriers such as the model described in this thesis are required. The affordability of this model including training teachers and teaching assistants to deliver intervention may mean it's more accessible and feasible for other SEN schools to implement.

Effective teaching strategies

Collectively the control group study and age comparison study add to the emerging research base into ABA intervention models which deliver a lower number of direct 1:1 teaching hours and more specifically DTT. As lower amounts of DTT are being delivered within these models it is vital to maximise teaching by ensuring teaching strategies are as efficient and effective as possible. Consequently, the evaluation of specific strategies and components of DTT become fundamental in ensuring the most efficient strategies are employed.

Existing research around instructions, prompting, error correction, reinforcement, data collection, and mastery criteria was discussed. The review of the literature into mastery criteria revealed many of the experimental evaluations to date have been conducted with neuro-typical college students, (Carlson & Minke, 1975; Fienup & Broadsky, 2017; Johnston & O'Neil, 1973; Keller, 1968; Semb, 1974), thus outcomes cannot be readily generalised to populations with developmental disorders and LD's.

Clinical judgement and experience have been largely guiding practitioners working with children with ASD and LD's. A large scale survey reported the most commonly used mastery criteria amongst practitioners is 80% (Richling, Willams, & Carr, 2019), whilst some initial research conducted with children with intellectual disabilities and/or ASD from Fuller and Fienup (2017) and Richling et al. (2019), has demonstrated higher more stringent mastery criteria has more positive effects on skill maintenance. Thus, the third study sought to investigate this further, whilst aiming to extend the currently limited research base into the effects of mastery criteria on the maintenance of skills.

The effects of 80%, 90%, and 100% mastery criteria on the maintenance of skills were evaluated. Results from this study indicated teaching skills to 100% mastery criteria led to skills maintaining more effectively over a four-week period following the termination of teaching sessions. Skills taught to a 90% criteria maintained less effectively than those taught to a 100% criteria, but more effectively than those taught an 80% criteria. Consistent with those of Richling et al. (2019) the results of this study suggested higher or more stringent mastery criteria result in higher levels of skill maintenance. These preliminary data indicate 80% mastery criteria may not be sufficient in maintaining skills following the cessation of teaching. This could have important clinical consequences, seeing as the outcomes of a survey of clinical practices indicated 80% mastery criteria was the most commonly adopted by practitioners (Richling et al., 2019). Teaching to 80% may mean skills do not maintain effectively and some reteaching may be required at a later date. Teaching to a higher criteria from the beginning could, therefore, be more time and cost effective. Further evaluation is necessary to confirm this, as well as advance understanding in this area.

The third study was limited by its utilisation of only one set of skills; a receptive identification task, making it difficult to generalise to other tasks. Future research should attend to how mastery criteria effects the maintenance of other skills, such as tacting, intraverbals, and visual performance tasks, etc. Larger sample sizes should also be utilised as well as populations with and without developmental disorders and LD's. Future investigations should also focus on specific components of mastery criteria itself, along with other variables which could potentially be affecting the maintenance of skills, such as teaching procedures, generalisation procedures, and schedules of reinforcement.

Real-world research

This thesis has described and evaluated an ABA intervention model which has added to real-world research applications of ABA. It has achieved this by developing and employing interventions in real-time with school-based staff on-site. Both studies one and two, have tested the fit of the model in an existing UK SEN school setting. Conducting research on-site in collaboration with school-based staff meant practice could be adapted to fit the existing local context and culture of the school. Immediate feedback from staff could be collected and adaptations made in real-time whilst preserving the essential components of the model.

A number of procedures were in put place to protect the integrity of the model and ensure strategies and elements of the model were utilised as designed. A series of formal and informal arrangements were made to ensure procedural integrity. Informal arrangements involved ensuring each pupil had their own individual programmes targets which were set with relevant teaching protocols and criteria, all staff were required to refer to these ahead of teaching. Written behaviour support plans also specified specific proactive and reactive strategies for behaviour management for each pupil. All teaching staff were trained in the implementation of ABA teaching strategies and behavioural support. Follow up training and supervision was provided to ensure strategies were being employed correctly. More formal procedural integrity checks were employed to ensure the correct implementation of strategies. Procedural integrity was measured using event recording, staff were observed implementing the strategies and scored for implementation of each component of a strategy. Procedural integrity was found to be high in both studies, this is important as ensuring procedural integrity is central for both the dissemination of evidence-based practices and quality improvement of services (Perepletchikova, 2011).

Social validity was similarly found to be high across the two studies. Staff implementing the model reported it to be suitable to the setting and agreed pupil specific interventions targeted areas of social importance. Returning to the concept of contextual fit within real-world research, the model outlined in the first two studies has been developed and implemented on-site with staff, thus local context was considered from the outset and throughout implementation. Horner et al. (2014) suggests good contextual fit is said to exist when implementers, recipients and stakeholders recognise the intervention is acceptable, doable, effective, and sustainable. In light of this and on reflection of the two studies it could be suggested there was good contextual fit to some degree, with staff reporting via questionnaires that interventions were acceptable, doable, and effective. Good contextual fit was in part key to the success of the model.

This work has focused on the integrity of the intervention and moderators and mediators of the intervention as recommended by Research Autism (2017). Despite the complexity of the project and the intervention model specifically, important aspects of the intervention have been described as recommended by Lechago and Carr (2008), including where possible details of programme personal, teaching, procedures, maintenance, generalisation, data collection, duration, and intensity.

The success of the model

The success of this model is ultimately evidenced in the pupil outcomes, and their individual achievements are celebrated with much excitement. Whilst pupil success was the ultimate aim and motivation for the project; the practicalities of the model required a high level of attention to be the vehicle for effective adoption. The model was successful for a number of reasons relating to affordability, practicality, and acceptability. Firstly, the model was affordable for the school to adopt, only the cost of hiring a behaviour analyst was incurred; there were no additional staffing costs as all teaching staff were trained to deliver interventions daily. Theory training was delivered during staff inset training hours and practical training was delivered in the classroom with both the staff and the pupils during the school day, as such no additional costs for covering staff during training were incurred. No major adaptations were required to the classroom and most of the teaching resources were already available within school. The affordability of the model made it more feasible for the school to adopt in the first instance. Further work is required to look at cost and the long-term effects of the intervention model. A cost-benefit analysis is required to determine whether a school-based ABA intervention model such as this could be cost effective over time.

Secondly, the model was successful because it was adapted to fit within the existing context and culture of the school. Staff were able to feedback throughout the process and the behaviour analyst was able to respond in real-time on-site to overcome issues.

Anecdotally some challenges related to staff and timetabling were initially faced, but soon overcome. Staff training began with the behaviour analysts pairing and building rapport with staff, however, two staff members held some misconceptions around ABA. This was difficult to manage initially during the early stages of training. Asking staff to test or try using strategies and feedback on them was particularly beneficial. Selecting behaviours and skills with which results could be seen very quickly also helped; this way strategies were demonstrated to be effective with staff and the pupils were beginning their programmes positively and successfully. Pupils skill acquisition soon became a powerful reinforcer for staff and as such their engagement with the programme and with teaching strategies grew. Those who initially presented challenges with their misconceptions initially soon became the biggest advocates, and reportedly were the first to request to be placed in a class using ABA intervention the following academic year.

Some initial challenges were also met with regards to timetabling 1:1 sessions and group teaching sessions, this was overcome by working in collaboration with the school-based team to create an innovative timetable, whereby pupils could carousel between 1:1 sessions, group teaching sessions, and other daily school-based activities. Pupils were still able to access all their usual activities, as well as school plays, sports days, and community visits and trips. Access to these activities was important for both the pupils and for the stakeholders. Anecdotally the stakeholders particularly valued these activities and encouraged all pupils to be included in them. Ensuring the pupils could still part take, meant it not only developed pupils experiences, but increased the acceptability of the model for stakeholders.

Thirdly, working in collaboration with other professionals and having a high level of staff involvement was also key to the success of the model. Staff training was provided to extend knowledge, develop skills and empower staff. On-going staff training and support was provided throughout. Staff were involved in the implementation of the model from the very beginning meaning they were able to take ownership and assist in its development.

Alongside the local context the wider context was additionally considered. It is suggested the model employed in these studies also sits well within the wider context of special education in the UK. The SEND Code of Practice (DfE, 2015) stipulates that educational settings should have a good understanding of pupil's strengths and needs and address them using effective evidence-based intervention. This model does precisely this, by conducting individual assessments it ensures a good understanding of individual pupils strengths and needs and addresses them using evidence-based interventions which have been demonstrated to be effective. In addition to this, the DfE (2019) is reporting ASD as the primary diagnosis for pupils with EHCP's, thus it undoubtedly makes sense to be exploring this model which provides support for pupils with ASD and LD's in line with stipulations outlined in the SEND Code of Practice (DfE, 2015).

In a white paper by Metz (2016), the effectiveness of interventions is considered in the context of implementation science. Implementation science involves identifying the supporting conditions for the effective implementation of an innovation, this may include a new service model or an evidence-based intervention or programme. Implementation science works on the following formula: effective innovation, plus effective implementation, plus enabling contexts, results in positive outcomes. The three elements refer firstly, to what is implemented, secondly, how it is implemented and thirdly, where it is implemented. Metz (2016) suggest significant impact is achieved if the innovation is well defined and corresponds well to the needs of the population, is implemented in a considered and adaptive manner, and is supported by a hospitable environment and learning processes. In light of this, it is suggested the ABA intervention model outlined in this thesis is on its way to achieving significant impact. The ABA intervention model is well described, corresponds to the needs of pupils with ASD, has been implemented in a considered and adaptive manner, and was supported in a hospitable environment, alongside positive learning processes. The principles which underline the intervention guide practitioners decisions, ensure consistency, integrity, and sustainable effort. Clear description of the essential components of the intervention are given to ensure the intervention is “teachable, learnable, doable, and assessable” across contexts. Practical assessments of performance were used to determine if the intervention is implemented as intended. Fidelity or integrity assessments were used to improve practitioner competencies and implementation. All these factors are required for the intervention model to be considered useful in practice (Metz, Bartley, Blase, & Fixsen, 2011; Fixsen, Blase, Metz, & Van Dyke, 2013 as cited in Metz, 2016).

Conducting research in a real-world setting, considering local context, wider context in the UK, ensuring procedural integrity, social validity, and contextual fit helps remove barriers to implementation and bridge the gap between research and practice. Further research into this model is certainly necessary. Replications across different cohorts and different educational settings is required. Beyond this model more research conducted within existing school settings in this way is required. With further research and development, it is hoped a strong comprehensive bridge between ABA research and practice can be constructed.

Contributions to the evidence base

Collectively all three studies contribute to the ABA research base by adding new knowledge and expanding on existing knowledge. The initial works have expanded the evidence base for ABA intervention models which can be delivered within existing school settings. The first and second studies have demonstrated the effectiveness of ABA interventions implemented within existing special needs school settings, whilst evaluating the effectiveness of a model in which behaviour analysts worked successfully with school-based teaching teams to design and implement function-based behaviour support plans, individual education programmes, utilise ABA teaching strategies, and promote the generalisation of skills. The application of this model has been compared to a control group who received EAU and demonstrated how pupils receiving ABA intervention made greater gains in adaptive behaviour, including significant gains in language and communication, socialisation, and daily living skills. Study two demonstrated how the ABA intervention model can be utilised to target a comprehensive range of behaviours and skill development across the key stages for older children and adolescents, as well as young children.

The first study in this collection is the first of its kind in the UK to investigate the application of such a model and include a control group. The second study is the first of its kind in UK to extend such a model across a wide age range of children and adolescents. Jointly these two studies not only expand knowledge but help to bridge the gap between the research evidence and practical application of ABA within schools. The studies bridge this research practice gap by describing and evaluating an ABA intervention model which has been developed and implemented on-site, under real-world conditions within an existing special needs school setting in the UK.

Both studies join a small number of other studies which have demonstrated effective applications of ABA within school settings (Eldevik et al., 2006; Foran et al., 2015; Peters-Scheffer et al., 2010, 2013). In line with these studies pupils have benefited from these interventions and have demonstrated some significant gains in adaptive behaviour.

Together the studies also contribute to the emerging research base for school-based ABA intervention models which provide a lower number of direct 1:1 teaching hours, but include support throughout the day from ABA trained school staff who provide function-based behaviour support and group teaching.

Lastly, the specifics of teaching within the model including strategies, such as instructions, prompting, error correction, reinforcement, data collection, and mastery criteria were explored. With the final study focusing on an under researched area; the effects of mastery criteria on the maintenance of skills. This study has provided some interesting preliminary findings and adds to the limited research base in this area.

Together all three studies contribute new knowledge to the education of children with SEN, specifically to those with ASD and related disorders, as well as add to the field of ABA as a whole. Research such as this which considers how ABA can be utilised affordably and as part of standard provision are essential in understanding how best to allocate funding and ultimately public resources. Finally, it is hoped these contributions result in more pupils accessing and profiting from more effective evidence-based interventions.

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Appendix A: Ethical approval for age comparison study

COLEG BUSNES, Y GYFRAITH, ADDYSG A GWYDDORAU CYMDEITHAS

COLLEGE OF BUSINESS, LAW, EDUCATION AND SOCIAL SCIENCES

PRIFYSGOL
BANGOR
UNIVERSITY

25th July 2016

Dear Laura Pitts

Re: Implementing low intensity behavioural intervention in a UK special needs school

Thank you for your recent application to the CBLESS Research Ethics Committee.
I am writing to confirm permission, on behalf of the CBLESS Research Ethics Committee, for the commencement of your research project.

I wish you well with your research.

Yours sincerely

Diane Seddon
Chair, CBLESS Research Ethics Committee

PRIFYSGOL BANGOR, CANOLFAN WEINYDDOL BANGOR, GW YNEDD, LL57 2DG. FFÔN: +44 (0) 1248 383231 FFACS: +44 (0) 1248 383228 EBOST: Cbless@bangor.ac.uk

BANGOR UNIVERSITY ADMINISTRA TIVE CENTRE, BANGOR, GW YNEDD,LL57 2DG TEL: +44 (0) 1248 383231 FAX: +44 (0) 1248 383228 EMAIL: Cbless@bangor.ac.uk

YR ATHRO/PROFESSOR PHIL MOLYNEUX BA, Mphil, PhD DEON Y COLEG/DEAN OF COLLEGE

Registered charity number: 1141565

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Appendix B: Ethical approval for mastery criteria study

COLEG BUSNES, Y GYFRAITH, ADDYSG A GWYDDORAU CYMDEITHAS
COLLEGE OF BUSINESS, LAW, EDUCATION & SOCIAL SCIENCES

YR YSGOL ADDYSG
SCHOOL OF EDUCATION

PRIFYSGOL
BANGOR
UNIVERSITY

09/08/2018

Cyf./Ref.: 18-31

Annwyl/ Dear Laura Pitts

Yng/ Re: Mastery Criteria and the Maintenance of Skills

Diolch am eich cais diweddar i Bwyllgor Ymchwil Moeseg yr Ysgol Addysg.

Mae'r pwyllgor wedi ystyried eich cais, ac fe wyf yn awr mewn sefyllfa i roi caniatâd, ar ran y Pwyllgor Ymchwil Moeseg yr Ysgol Addysg, i chi gychwyn eich prosiect ymchwil.

Dymunaf yn dda i chi gyda'ch ymchwil.

Thank you for your recent application to the School of Education Research Ethics Committee. The Committee has considered your application and I am now able to give permission, on behalf of the School of Education Research Ethics Committee, for the commencement of your research project.
I wish you well with your research.

Yr eiddoch yn gywir/ Yours sincerely

Dr. Marguerite Hoerger
Chair, School of Education Research Ethics Committee Cadair, Pwyllgor Ymchwil Moeseg Ysgol Addysg

PRIFYSGOL BANGOR SAFLE'R NORMAL, BANGOR, GWYNEDD, LL57 2PZ FFÔN: (01248) 383082 EBOST: addysg@bangor.ac.uk

BANGOR UNIVERSITY NORMAL SITE, BANGOR, GWYNEDD, LL57 2PZ TEL: (01248) 383082 EMAIL: addysg@bangor.ac.uk

YR ATHRO/PROFESSOR ENLLI MÔN THOMAS PENNAETH YR YSGOL ADDYSGHEAD OF THE SCHOOL OF EDUCATION
FFÔN / TEL: (01248) 383053EBOST / EMAIL: enlli.thomas@bangor.ac.uk

www.bangor.ac.uk www.bangor.ac.uk/addysg

Appendix C: Control group study and age comparison study- Staff Training Checklist

Staff Training Checklist

Staff member: ______________________________ Supervisor: ______________________________

Date: ____________________ Pupil: ______________________ Setting: ______________________

Description of component	Theory Training Provided	Knowledge checked/ Observed during Practical Training	Not Observed during Practical Training	Comments
Knowledge and understanding of what ABA is				
Knowledge and understanding of what ABA Programmes for individuals with ASD are				
Understanding Behaviour; Types of behaviour				
ABC of behaviour				
Knowledge and understanding of types of reinforcement				
Knowledge and understanding of motivation and factors which affect it				
Knowledge and understanding of reinforcer sampling/ stimuli preference assessment				
Effective use of reinforcement				
Pairing Tutor pairing, pairing of environment, teaching stimuli/materials				

Description of component	Theory Training Provided	Observed during Practical Training	Not Observed during Practical Training	Comments
The process of pairing, generating mands/requests before placing demands				
Skills Teaching: DTT (Procedural integrity checklist)				
Prompting; Type of prompts, effective prompting and prompt fading				
Error correction				
Knowledge and understanding of shaping				
Knowledge and understanding of chaining				
Imitation and modelling				
Matching to Sample				
Discrimination				
Incidental teaching/NET				
Skills teaching; Data collection, mastery criteria and skills tracking				
Knowledge and understanding of behaviour of concern and its functions				
Knowledge and understanding of behaviour reduction strategies				

Description of component	Theory Training Provided	Observed during Practical Training	Not Observed during Practical Training	Comments
Behaviour of concern; Data collection				
Generalisation Across stimuli, settings and people				
Maintenance				

Pupil Specific Training	Theory Training Provided	Observed during Practical Training	Not Observed during Practical Training	Comments

Areas for further revision:

Additional notes or comments:

Staff member: ______________________ Signature: ______________ Date: ___________

Supervisor: ______________________ Signature: ______________ Date: ___________

Appendix D: Control group study and age comparison study- 1:1 discrete trial teaching procedural integrity checklist

Discrete Trial Teaching Observation Feedback Form

Staff Member: ___________________________ Supervisor: ________________________________

Date: ______________________ Client: ________________________ Setting: _______________________

Description of component	Observed	Not Observed	Comments
Material/Stimuli organised prior to beginning session.			
Work space organised prior to beginning session; unnecessary distractors removed or minimised.			
Material/Stimuli and reinforcers easily accessible to instructor.			
Instructor sits and positions themselves appropriately and at optimal distance from pupil.			
Instructor ensures they have pupils attention before delivering SD.			
SD is clear, specific and delivered without interruption.			
Both SD's and stimuli presented in a fluent manner.			
Prompts used appropriately and effectively.			
Error correction followed appropriately when required.			
Reinforcement delivered appropriately and in timely manner.			
Inter-instruction intervals of appropriate length; teaching pace suitable for pupil and appropriate to maximise motivation.			

Areas for further revision:
Improvements since last observation:

Appendix E: Control group study- behaviour support plan procedural integrity checklist

Procedural Integrity: Behaviour Support Plan

Supervisee: ____________ Supervisor: ____________ Date: ____________ Pupil: ________ Setting: ________

Description of Component	Yes	Partially	No	Comments
Proactive Strategies				
Reinforcement provided for appropriate behaviour.				
Requesting encouraged and communication programme run frequently (as described on plan/individual programme sheet).				
Movement breaks given when required/appropriate.				
Evidence of pairing/rapport building.				
'Downtime' limited and appropriate activities given to pupil to complete.				
All presented instructions are followed through on.				
Reactive strategies				
If intervention is necessary for safety; staff intervene neutrally (i.e. without words, eye-contact and with as little physical contact as possible; blocked or terminated behaviour of concern (check plans for details).				
If an instruction has been presented, staff have followed through with instruction.				
Access to preferred items/activities limited until engagement in behaviours of concern have ceased and simple instructions are being followed.				
Appropriate time allowed before delivering appropriate rates of reinforcement once again (i.e. attention). Please check plans for intervals.				
Data Collection				
Incidences of behaviour recorded on data sheet.				

*Further details of all strategies can be found on behaviour support plans.

Appendix F: Mastery criteria study- Data sheet

Participant Number: **Phase:**

Data Sheet

Target: **SD:** Presentation of 3 word cards and "Touch …"

Session Number	Trial Number										% Correct
	1	2	3	4	5	6	7	8	9	10	
1	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
2	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
3	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
4	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
5	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
6	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
7	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
8	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
9	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
10	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
11	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
12	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
13	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
14	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
15	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
16	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
17	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
18	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
19	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
20	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
21	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
22	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
23	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
24	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	
25	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	✓ P X	

Appendix G: Mastery criteria study- Baseline sessions procedural integrity checklist

Procedural Integrity Checklist- Baseline Sessions

Staff Member: ______________________ Observer: ____________________________ Date: _____________________ Participant: ______________________

Step	Description of component	Observed (Please tick)	Not Observed (Please tick)	Comments
1	A baseline session has not been conducted for at least half an hour.			
2	Participant seated on chair at table.			
3	Places correct stimuli set on the table in front of participant.			
4	Looks at participant (ensures attention) and presents instruction "Touch…"			
5	Correct responses do not receive reinforcement Incorrect responses do not receive error correction.			
6	Circles a tick if participant touches correct stimulus. Circles cross if participant touches incorrect stimulus or does not respond within 5 seconds.			
7	Repeats steps 2-6 for subsequent trials.			

Appendix H: Mastery criteria study- Intervention sessions procedural integrity checklist

Procedural Integrity Checklist- Intervention Sessions

Staff Member: ______________ Observer: ______________ Date: ______________ Participant: ______________

Step	Description of component	Observed (Please tick)	Not Observed (Please tick)	Comments
1.	An intervention teaching session has <u>not</u> been conducted for at least half an hour.			
2.	Reinforcement identified and token board set up.			
3.	Participant seated on chair at table.			
4.	Places correct stimuli set in front of participant.			
5.	Looks at participant (ensures attention) and presents instruction "Touch…"			
6.	Uses least to most prompting procedure to prompt participant as required.			
7.	Correct responses receive reinforcement Incorrect responses receive error correction: provides feedback such as "not quite' or "try again", reissues instruction and immediately prompts the correct response. The same instruction is then repeated to give the participant the opportunity to respond independently.			
8.	Circles a tick if participant touches correct stimulus. Circles cross if participant touches incorrect stimulus or does not respond within 5 seconds. Circles 'P' if prompt is given.			
9.	Repeats steps 3-8 for remainder of session.			

Appendix I: Mastery criteria study- Maintenance probe procedural integrity checklist

Procedural Integrity Checklist- Maintenance Probes

Staff Member: ______________________ Observer: ____________________________ Date: _____________________ Participant: ______________________

Step	Description of component	Observed (Please tick)	Not Observed (Please tick)	Comments
1	An intervention teaching session or maintenance probe has not been conducted for at least one week.			
2	Participant seated at table.			
3	Places correct stimuli set in front of participant.			
4	Looks at participant (ensures attention) and presents instruction "Touch…"			
5	Correct responses receive reinforcement. Incorrect responses do not receive reinforcement or error correction.			
6	Circles a tick if participant touches correct stimulus. Circles cross if participant touches incorrect stimulus or does not respond within 5 seconds.			
7	Repeats steps 2-6 for subsequent trials.			