Devising and Assessing an Intervention to help Extend the Attention Span of a Child with Cerebral Palsy

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Declaration and word count

I hereby declare that, except where explicit attribution is made, the work presented in this thesis is entirely my own.

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M L Y Carter

Abstract

Literature suggests that children with developmental impairment of motor skills may have an increased risk of disorders of learning, including attentional and working memory (WM) difficulties, which may remain undetected. Whilst there are many clinical studies which focus on limb function and movement, very few studies have explored the cognitive difficulties of children with cerebral palsy (CP).

Among cognitive difficulties, working memory (WM) and attention seemed particularly important. In the present research, an extensive pilot focusing on working memory identified insuperable methodological difficulties. The study therefore focused instead on sustaining attention (readily identifiable from observed behaviours) and on testing the ability of an intervention to increase attention. The research consisted of close observation of a single individual with CP in a single-case study design.

The present study, within the action research paradigm, incorporates some features of single case methodology; specifically, of the ABA withdrawal design. The design consisted of three phases: A no-intervention baseline phase (A), an intervention phase (B), and a no-intervention withdrawal phase, followed by return to a (new) baseline (A). The initial baseline assessment involved a series of observations during unstructured play sessions. This was to establish typical movement patterns for the participant with CP so that these could be distinguished from later movement patterns associated with the interventions.

The idea of ‘pattern’ was the central concept chosen for the intervention because it is central to mathematical understanding and is part of the school curriculum. Activities were planned which were not being taught or practised at other times. Sustained improvement in attention in successive baselines would suggest the intervention programme was successful in effecting a stable change. Results demonstrate the intervention was successful in supporting a child with cerebral palsy to develop his attentional ability. This was evidenced through increased time on-task across the intervention. The child was able to choose what to pay attention to and what to ignore when undertaking adult-led learning tasks.

Impact Statement

Findings of The Deployment and Impact of Support Staff (DISS) Project, conducted between 2003 and 2009, highlighted that more support from Teaching Assistants did not lead to better progress made by children. Despite these findings, children often remain overly supported, leading to possible dependency and poor educational outcomes.

The present research study supports the findings of the DISS project and provides an opportunity for stakeholders to consider the implementation of policies that target effective support for children with special educational needs and disabilities.

The allocation of funding which supports inclusive practice through cost effective programmes of targeted intervention will make better use of limited resources, at a time when education, health and social care services are over-stretched. The potential impact will be better use of resources and public money to improve outcomes.

This research has the potential to contribute to further research that considers effective educational approaches to supporting associated attentional difficulties of children with some types of cerebral palsy. This could lead to evidence-based interventions which improve attentional control and increase educational outcomes for the child. Through increased engagement children learn to be actively involved in activities, to think about what they are doing and to develop the skills needed to be independent life-long learners. Improved educational outcomes contribute to the child's sense of self-worth, emotional wellbeing and mental health.

This research has provided a valuable opportunity to gain insights through increased understanding of the difficulties and approach needed to support a child with cerebral palsy within a mainstream setting. The impact on Bob, the child in the main study, has been improved engagement in activities, which was systematically measured and evidenced through increased time on-task.

The teaching assistant involved with Bob benefitted. Involvement in the intervention through observation provided an opportunity to observe a different

approach that effectively supported Bob's engagement with activities and enabled progress.

This research has the potential to increase awareness amongst both stakeholders and practitioners of the potential of children like Bob, to make educational progress with targeted intervention. It challenges the current model of mainstream practice whereby all children follow a curriculum devised for typically developing children, with an expectation that they make age-related progress measured against national norms. This research highlights the need for a new pedagogical approach to meet the complex needs of children like Bob, attending mainstream schools.

This research has impacted my practice as a specialist advisory teacher. I would argue that, regardless of medical diagnosis, an understanding of the child's cognition is essential. This awareness has been raised amongst other practitioners in the researcher's team. The impact has been developing more holistic assessment of children's learning needs, instead of a focus on the physical access arrangements and environmental adjustments required. When meeting with stakeholders I endeavour to implement decisions through increasing awareness of the problems facing mainstream schools in meeting the needs of children like Bob, and by highlighting how an alternative approach is needed, which endorses the findings of the present study.

Acknowledgements

I feel privileged to have been able to work with so many children over the years, especially children with disabilities. They have been a source of inspiration in the way they face their daily challenges with persistence and determination. Without knowing, they have provided the motivation to keep going despite the many difficulties encountered during these studies.

I owe my sincere thanks to my supervisor, Dr Yvonne Reynolds, who supported me throughout my thesis journey with guidance, patience and kindness.

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Reflective Statement

In this reflection I provide an overview of the areas covered across the course of the programme and the links between each element. I highlight the insights gained and how the process has supported my development as a researcher and practitioner working within the field of special educational needs and disabilities (SEND).

Foundations of Professionalism

This module covered a wide range of issues relating to professionalism and the modern concept of what constitutes a 'professional'. The lectures covering the role of policy and politics in Education were particularly interesting whilst the link between some theorists such as Foucault, provided a different perspective on education and practice. When considering my own journey as a practitioner and professional I reflected on the difficulties I had encountered when moving from teaching within a mainstream environment to a specialist school for children[1] with the most profound learning difficulties in society. My mainstream experience provided opportunities to develop a range of effective skills to support the learning and development of children. I felt confident within my professional role which was endorsed through feedback received from the Office for Standards in Education (OFSTED). The transition to working in a highly specialist field within a special school environment resulted in feeling totally deskilled. During this time I was required to undertake a mandatory qualification in teaching children with a multi-sensory impairment (MSI). This led to a journey of new learning and a realisation that research provided a powerful tool to focus on my practitioner quandaries and problems which the literature did not answer.

The first assignment set out to explore the importance of integrating theory and practice and I attempted to carry out a small piece of empirical research to examine how a group of teachers had felt when they first embarked on transition from mainstream practitioner to specialist teacher. I considered the demands within the teaching profession emanating from government intervention, the tensions between different professionals and the lack of

[1] The term children is used to include children and young people

specialist guidance within national documentation.

My conclusions highlighted the difficulties specialist teachers face as professionals and how feeling deskilled as practitioners is common. Additionally, I attempted to examine teacher autonomy, globalisation and market productivity in relation to special education.

Feedback on the assignment from the second marker noted, 'It was hard to find a clear theme running through it'. In subsequent work I have endeavoured to provide a convincing argument and make claims that can be substantiated through the research and literature.

Methods of Enquiry 1 (MOE1)

Whilst working at the special school, I was appointed to the role of Assessment Manager. For this assignment I decided to focus on an aspect of assessment within my pupil group; children with profound and multiple learning difficulties (PMLD) and multi-sensory impairment (MSI). I considered the literature and tried to demonstrate how the P Level descriptors (an assessment for pupils working below Level 1 of the National Curriculum) did not provide the very detailed measure of progress for children at the earliest stages of development. I highlighted some of the language used in these descriptors including the terms **familiar** and **recognise.** This implied the children had memory although my practitioner reflections questioned whether daily routines were being remembered. This assignment was pivotal in changing my focus for the Institution-focused study (IFS), from a play based assessment to an enquiry based on memory.

I read journal articles relating to memory and memory research and familiarised myself with different types of memory and research methods. A particular difficulty I encountered was finding up-to-date research specifically looking at memory in children with profound and multiple learning difficulties. This emphasised the relevance of my research and the importance of considering the role of memory in learning for this population of children.

Methods of Enquiry 1 provided scope to consider relevant research methods within the field of special education. Feedback from the second marker stated, 'The theoretical framework lacks understanding and therefore weakens the

proposed research.' I subsequently tried to develop this during Methods of Enquiry 2.

Efforts to improve the literature review in this assignment were partially met. The first marker commented that, 'The literature review covers issues around PMLD and memory, but there could have been a more critical assessment of the literature.' This was an area I focused on in the next module. I believe the progress I made from the first assignment was in creating a coherent argument, which had been an area for development. Feedback for MOE1 noted, 'There is structure and a sense of argument throughout the work.'

Initial Specialist Course: Using psychoanalytic perspectives to make sense of education and educational research

This assignment, whilst not linking to memory, provided an opportunity to explore the impact of disability on parent-child relationships within special education. Many children with profound learning difficulties have complex and often life-limiting medical conditions. As child death was something that had to be faced, I felt it would be helpful to explore this in relation to psychoanalytic perspectives. On the course, we covered Freud's essay 'Mourning and Melancholia' (1917) and a colleague who had experienced the death of her own child recommended the work of Darian Leader.

This time was difficult and painful on a personal level and I was unable to cope with reading literature on loss and grief. I therefore changed the focus to attachment theory. This provided considerable insights on the impact of disability on the parent-child relationship. This has helped me to understand why some parents can project anger towards professionals due to 'displacement'. I did not feel comfortable approaching parents for their perspectives and therefore only considered the research literature. The first marker felt, 'A more detailed and precise exploration of concepts/theories and the way these might help you to understand specific interactions in your workplace might have enabled you to develop a more distinctive argument of your own in relation to these ideas.' This was an area for development although I was now developing a more cohesive style of writing as noted by the second marker, who commented, 'clear sense of argument'.

Methods of Enquiry 2 (MOE2)

MOE2 provided an opportunity to address the points for development highlighted from the feedback in MOE1. I therefore set out to address the following:

- To ensure I had a sound understanding of the theoretical framework
- To incorporate a more critical assessment of the literature
- To include more assessment of the literature around the methods.

MOE2 was an interesting process although I found it extremely challenging. The study did not answer my research question although I felt the design could be successful with modification. As the module aim was to develop research skills, I felt it was a very valuable learning opportunity

During MOE2 I started to develop research skills and I interviewed two Learning Support Assistants using a semi-structured interview schedule. The interviews were taped using a dictaphone which provided a valuable opportunity to listen to the interviews and reflect upon my interview technique. I also transcribed the interviews which enabled me to reflect upon the language used and style of questioning. The issue of power relations was raised by the first marker in the draft feedback and I looked through the transcriptions to decide whether there was evidence that my position as a manger influenced the responses provided to questions. However, I do not believe this happened because there were many occasions when the interviewees disagreed with my views. Feedback from the second marker commented that, 'The basis for the quantitative analysis of the interview responses is unclear and possibly problematic, since it may have been skewed by a single verbose individual with fixed ideas.' This highlighted issues firstly, from undertaking research as an insider researcher and secondly, the need to gain wider representation when including practitioner views. The strength of this module was developing my understanding of research methods carried out by psychologists in memory and learning,

Feedback on the draft for MOE2 commented, 'You critically interrogate the literature, including the difficulties you faced, and, indeed it must have made the research question seem daunting.' In the final feedback the same marker commented that the work, 'Demonstrates a critical interrogation of the surrounding literature, and a high level and understanding of methodological

issues.'

Reflection on research and other generic skills acquired or enhanced

Overall, the taught modules provided opportunities to develop an understanding of issues relating to disability, different methodologies and literature within this field.

Institution-focused study

The aim of this research study was to explore memory in children identified as having profound and multiple learning difficulties (PMLD) using a case study approach. This linked directly to the work carried out for MOE1 and 2 and my ongoing practitioner concerns that some children do not make measurable progress, when assessed against the P Level descriptors. Comments from MOE2 were considered and interviews with eight teachers were included to gain greater representation of views and perspectives. Feedback highlighted the methodological challenges I had faced whilst also acknowledging the group of children, 'Have received little attention from the research community'. Further feedback recommended, 'A clearer and more explicit presentation of procedure related to the specific content', and this has been addressed in the thesis. A further suggestion was to consider, 'What may constitute progress for these pupils?' Whilst the child in the study in the thesis did not have PMLD, I ensured that progress was explicitly considered. This was achieved through systematic measurement of on-task behaviours which were recorded across the intervention. The improvement evidenced showed progress in the child's ability to sustain attention.

The Thesis

The thesis was undertaken after I changed job roles and returned to mainstream education as a specialist advisory teacher, employed by a Local Authority. The role involved providing advice and guidance to mainstream primary and secondary schools for children and young people with a physical and/or neurological impairment. The thesis provides an account of why memory was the initial focus but changed to attention due to a number of methodological challenges, which are also outlined.

The video observations, included in the data collection methods, necessitated months of systematic analysis as every movement required careful and precise coding. The level of detail and scrutiny required was challenging in terms of time. Repeatedly watching the video recordings was needed to check every interval of time had been coded accurately. However, the process of coding the data has enabled me to develop the ability to systematically observe behaviour in detail. I feel assured that the findings of this research are grounded in thorough, methodical data collection and subsequent analysis.

The journey from the first module, Foundations in Professionalism, to the final write up of the thesis has been long and challenging. I have remained driven by my commitment to improve as a practitioner and to find answers to dilemmas. In the words of Felicity Armstrong, who supported me through the final stage of the IFS, 'All children have the right to be learners and to have access to appropriate resources and pedagogies to support their development' (IFS feedback).

Chapter 1: Introduction

1.1 Overview of the study

This chapter provides an account of the research problem and rationale for the research. My professional role and interest are described, including the development of this research from the Institution-focused study (Carter, 2013) which formed part of these Doctoral studies. Since this is a practice-based study my professional reflections are incorporated throughout.

This is a single-case study of a child, Bob[2], who attends a mainstream school within a Local Authority in South East England. Bob has a disability resulting from a medical diagnosis of cerebral palsy (CP), defined in Chapter 2 (section 2.3, page 28).

1.2 Context for the study and professional background

I work for Children's Services within a Local Authority managing a team of Specialist Advisory Teachers and practitioners who provide advice and guidance to schools, pre-school settings and families. This includes children and young people (referred to as children hereafter) 0-25 years with Special Educational Needs and Disabilities (SEND), including: autism, visual impairment, hearing impairment, multi-sensory impairment, and physical and/or neurological impairment. Prior to this, and at the time of the present study, I was a Specialist Advisory Teacher within the same service, providing advice on strategies and equipment to support the learning and access needs of children in mainstream schools with a physical and neurological impairment (PNI)[3].

My specialist knowledge evolved from working in mainstream and special school settings over many years, and from undertaking an additional mandatory qualification in multi-sensory impairment (MSI)[4].

1.3 Institution-focused study

As part of my doctoral work, my Institution-focused study (IFS) was undertaken during my employment at a special school while teaching children with profound

[2] Pseudonym
[3] Neurological conditions affect the brain and nervous system
[4] Deafblindness

and multiple learning difficulties (PMLD) and multi-sensory impairment (MSI). This cohort of children had a physical and neurological impairment, were non-verbal and either pre-intentional or intentionally communicative. These are the earliest stages of communication which are typically acquired at 0-3 months and 3-8 months respectively, whereas the chronological ages of the Institution-focused study cohort ranged from 4 to 18 years old. The children were reliant upon adult support to meet all of their daily care needs and some could only access resources with adult support, due to limited functional movement. The curriculum was centred on sensory based learning (Longhorn, 1998) and the creation of a responsive environment (Ware, 2003).

The focus of the IFS was suggested by my professional concern that the children in the special school were not remembering daily routines and even appeared not to be responding to their names. Its purpose was to identify common behaviours which could indicate that activities were remembered and that learning had taken place. Specifically, did the children seem to anticipate the order of steps in their daily activities and routines? Such behaviours might form the basis of an inventory that could be of real assistance to educators in planning and assessing the usefulness of learning programmes for these children. Findings suggested that it was possible to identify behaviours that indicated anticipation by observation.

1.4 My work in mainstream schools. Children with cerebral palsy.

By comparison with the children in the IFS, many pupils with a physical and/or neurological impairment (PNI) in mainstream schools for whom I provided advice and recommendations were very able. Many exhibited good conversational language and were able to access resources with varying levels of independence, according to their degree of physical impairment. These included some children with cerebral palsy (CP).

I became, however, specifically interested in five children with CP all of whom I observed to be experiencing difficulties in learning. The nature of problems appeared to extend beyond their physical impairment, although other causes had not been identified by school-based practitioners. The children were failing to meet age-expected targets in many areas of the national curriculum. Several of the children were receiving high levels of one-to-one support from teaching

assistants (TAs) which seemed to me to be further masking the difficulties. For example, an examination of the children's numeracy workbooks presented a picture of correct answers but when I asked the children to demonstrate practically 'two lots of three' they were unable to do so. This indicated that the work had been overly supported by a TA, which in turn suggested that difficulties had not been identified or appropriate interventions implemented. As a new member of the team, I discussed my concerns with the other teachers who were well established within their advisory roles. Although they had made similar observations, at that time they were more focused on providing advice and guidance around physical access to schools and the curriculum. Although children with CP formed the largest cohort of children referred to the service, it seemed to be a condition of which, as a team of specialist teachers, we had least knowledge. Examination of literature revealed that studies which examined and measured interventions focused on movement. Support needed for cognitive functions was little considered (Steenbergen and Gordon, 2006). The present study addressed this gap by looking at attention (Mullane, Lawrence, Corkum, Klein and McLaughlin, 2016) and expands the earlier work undertaken during the IFS by acknowledging the importance of attention in memory processes and in learning in general.

1.5 Focus of the current study

Building on the IFS, I developed the idea of constructing an observational instrument that could be used in everyday classroom practice to assess an important cognitive ability and to help plan interventions that would, if need be, improve that ability. The focus would be a child with cerebral palsy. The cognitive ability to be assessed and developed would be sustained attention.

The main focus of the present study is therefore the sustaining of attention. For the purpose of this research, attention is defined as focused awareness of stimuli, thoughts, or features of the environment (Dehn, 2014).

A child with CP was selected because children with cerebral palsy constitute the highest proportion of children the team supports. The learning domain selected was elementary mathematics, specifically pattern recognition and construction. This was because teacher assessments showed that this was a particular area of difficulty for children with CP (see section 2.14, page 48.) Sustained

attention was selected because it is essential in all kinds of deliberate learning, and because as a variable it is easily operationalised and observed as on-task behaviour. After much thought, I initially concluded that a 'case study' would do justice to the depth and detail I hoped to obtain about improving the learning experience and achievement of a child with CP. I reasoned that since my study concerned a single child, it should be classified as case study research with a single participant – synonymous, I then thought, with single-case design. However, in the literature, 'case studies' and 'single-case design' are not synonymous. They designate quite distinct methodologies. My methodology was *not* case study methodology. In fact, it has some of the features of single-case design, and many of those of action research – a third distinct methodology. The literature suggests that the three approaches, though distinct, developed together and to some extent overlap (Blichfeldt and Andersen, 2006; Lobo, Moeyaert, Cunha and Babik, 2017; Krasny-Pacini and Evans, 2018).

I discuss advantages and disadvantages of these three approaches in relation to my research questions at the beginning of Chapter 3 (section 3.2, page 53). Further justification of the choice of cognitive ability (attention) as the research focus, and of the domain (mathematics) are set out in detail below (sections 2.5 and 2.10).

1.6 The problem this research addresses

There is limited educational literature on the nature of learning difficulties for children with a medical diagnosis of CP. Although practitioner observations suggest many children are failing to make age-expected educational progress measured against national norms, the focus on difficulties centres around physical impairment and physical access issues. Heath interventions typically include physiotherapy programmes to develop functional movement skills and assessment by occupational therapists to provide specialist equipment.

There is thus a gap in knowledge pertaining to educational progress. Relevant literature, presented in Chapter 2, reveals contradictory findings. Limited strategies are identified to address learning difficulties in CP and appropriate evidence-based interventions. From my practitioner observations, many teaching assistants do not have the knowledge and skills to address the

learning difficulties. More worrying, by their own disclosure, they are sometimes expected to plan and deliver learning programmes without input from teachers.

Although many children with CP make good academic progress, others have needs that go beyond access to school premises and difficulties are only acknowledged by minor adaptation of the mainstream curriculum. Despite my experience and additional qualifications, I do not feel I have the *specialist* expertise needed to provide advice and recommendations on how to support the educational progress of children with CP. This problem provided the starting point for the present study and my practitioner interest in the learning of children with CP in mainstream schools.

1.7 Rationale and aims of the study

The rationale for the study arose from the current context in which *cognitive* needs of children with CP tend to be neglected in favour of physical needs. The present study addressed the former. The focus of the study was the improving of attention in a child with CP. The aim was to provide an appropriate educational framework in which attention could be assessed and trained over an intervention period.

1.8 Special Educational Needs and Disabilities legislation in England

This section provides an overview of current legislation. This is relevant to the present study because the child participant has a special educational need and disability (SEND). SEND denotes a range of difficulties which can affect learning, for example, concerning behaviour and social skills, dyslexia[5], concentration levels and physical ability.

The Code of Practice (2014) replaced the Special Educational Needs (SEN) Code of Practice, (2001). It provides statutory guidance based on Part 3 of the Children and Families Act 2014.
Key changes include:

- replacement of ‘Statements of SEN’ by ‘Education Health and Care Plans (EHCP)
- change in the age group from 2-19 to 0-25

[5] Characterized by trouble with reading despite normal intelligence

- increased integration between education, health and care provisions
- children and young people with SEND, and their families, central to the process.

The statutory Code of Practice (2014) provides details of the legal requirements and advice on how to carry out statutory duties. Under the Code of Practice (2014), there is a requirement for Local Authorities, schools, and other settings, to identify, assess and make provision for children's special educational needs. An Education Health and Care Plan (EHCP) is for children who need more support than is available through special educational needs support and sets out additional provision needed to meet identified educational, health and social needs.

The Equality Act (2010) regulates that schools cannot unlawfully discriminate against children with a protected characteristic, including disability. Schools can treat disabled children 'more favourably' than non-disabled children and are required to make 'reasonable adjustments' to ensure they are not substantially disadvantaged because of their disability. (Equality and Human Rights Commission, 2012).

I have observed as a practitioner that many schools view 'inclusion' as all children largely accessing the same curriculum with some differentiation of tasks to accommodate the more or less able children. However, increasing numbers of babies are surviving extremely preterm births[6] and will often have long-term health problems and disabilities (American College of Obstetricians and Gynaecologists, 2016; World Health Organisation, 2018). This population of children may be 'wired differently' (Carpenter, 2018) and will learn differently. These children, including some with CP, may benefit from an alternative curriculum to meet their learning needs.

1.9 Summary

This chapter provided an overview of the research problem which emerged from my role as teacher practitioner working with children with CP. I presented the overall aim of the research and outlined current legislation and duties on schools to make 'reasonable adjustments' for children with disabilities. I

[6] Born before 28 completed weeks of pregnancy

discussed the changing population of children attending mainstream schools and the educational challenges of meeting their complex health needs. I introduced the notion that pedagogy for children with atypical learning patterns is problematic and raised my professional concern that some children are not achieving age-related national norms.

In the following chapter key terminology is introduced and defined. I provide a review of the literature and consider the perspectives of present-day practitioners working in an educational context with children with cerebral palsy.

Chapter 2: A Review of Literature

2.1 Introduction

This Literature review considers the nature of cerebral palsy, since the participant in the study is a child with CP. Key terms are defined before an exploration of learning difficulties associated with CP are considered. Literature about attention, working memory (WM) and other factors which may affect learning in children with CP are presented. Due to the limited educational literature available, the views from present-day practitioners are considered, as their interpretations provide richer accounts of the difficulties identified amongst this population. The importance of the present study and rationale for a single-case is discussed.

In the following sections I discuss different models of working memory and attention and review relevant literature which guided the study. Whilst the focus of the study is sustained attention, WM has been included because both are cognitive functions that are required for almost all learning tasks used in the classroom, and they are closely interlinked. My interest in the importance of memory processes arose from my Institution-focused study, and an understanding of the interrelationship between WM and attention developed and deepened. This review demonstrates how attentional control precedes WM and thus recommended itself as the focus of the single-case study. In addition, I perceived as a practitioner that apparent attention problems were difficult to distinguish from WM difficulties in an everyday context. The review has been broadened to consider other possible factors that could have a bearing upon educational progress in children with CP and reasons why the sustaining of attention may be problematic for this population.

To address the problems outlined, the present study was informed by the following question:

1. Can the attentional capacity of a child with CP be improved?

Central to mathematical understanding is the concept of pattern which was chosen for the intervention. For that reason, a subsidiary research question concerning mathematical understanding was considered relevant:

2. What approach is needed to develop early mathematical understanding for a child with CP?

2.2 Search Strategy

A review of published educational studies and other research within the field of disability showed relevant studies to be sparse and specifically, information about cognitive abilities and development in CP (Straub and Obrzut, 2009). The inclusion of older literature provides some findings in the field in the absence of up-to-date published studies. An additional difficulty arises from the fact that many studies have included different populations of children with neurodevelopmental disorders[7]. Therefore, these studies have been of variable relevance to my particular professional and research interests. Although the search provided a range of studies there was a greater emphasis on hemiplegia CP, whereas my participant has a diagnosis of diplegia CP, but nonetheless it provided interesting findings about learning difficulties associated with CP in general.

The review comprised a search of library catalogues and electronic databases. Searches were undertaken by subject headings, themes and key words for the relevant concepts. Combinations were created by using Boolean operators whereby a search for selected information using 'and', 'or' and 'not' was incorporated to provide focused results. The following terms were used, in various combinations and truncations: attention; sustained attention; ADHD[8]; working memory; cerebral palsy; diplegia cerebral palsy; children; mathematics; early numeracy; pattern; on-task behaviours in children; off task behaviours in children; engagement; assessment; behaviour rating scale; single case study; ABA withdrawal design; movement/motor planning; hand function; object manipulation.

Sources of literature reviewed for this study were obtained through the Institute of Education, University College London library catalogue which included links to e-books, electronic documents, library books, theses and dissertations. This procedure generated a number of related articles and the reference pages provided links to additional material. Databases include British Education Index

[7] A disorder of brain function
[8] Attention Deficit Hyperactivity Disorder

(EBSCO); Education Index (ProQuest); Education Resource Information Centre (ERIC); Google Scholar; JSTOR; MEDLINE; PsycINFO; PubMed and Web of Science.

2.3 Key terms used in this thesis

Terms discussed below are predominantly from the fields of psychology and health but also feature in the educational literature reviewed subsequently.

Cerebral Palsy: etiology and types

Cerebral Palsy (CP) is an umbrella term encompassing a number of non-progressive neurological conditions that affect movement and coordination. It is understood to result from a defect, abnormality, or injury to the developing brain either before, during or after birth or during early childhood (Lynch, 2013; Rosenbaum et al., 2007). Risk factors include: low birth weight (less than 1,500 grams), premature birth (before the 37th week and especially before the 32nd week of pregnancy), multiple births, infertility treatments due to increase in preterm and multiple births, infections during pregnancy, jaundice and complications at birth (CDC, 2013). CP is the most common motor impairment in children (Uldall, et al., 2001).

Although CP is usually a non-progressive condition that presents in early childhood (Ropper and Brown, 2005) it may change over time. Therefore, whilst it is principally a disorder of voluntary movement and/or co-ordination, associated difficulties may be present. CP is often classified by the severity level:

- Mild: children can move independently and access daily activities without assistance.
- Moderate: children will need medical interventions and adaptive technology[9].
- Severe: children will use a wheelchair and need considerable adult support within daily activities.

[9] Any object or system that is specifically designed for the purpose of increasing or maintaining the capabilities of people with disabilities.

In addition to severity there are different types of CP: Spastic[10] CP is when the control of movement is disordered (Kenward, 1997) and this may involve speech difficulties. Different parts of the body may be affected:

- Hemiplegia: one side of the body
- Diplegia: two limbs (usually legs)
- Quadriplegia: all four limbs

This provides an overview of the different types of CP. Although there are other forms they are not described as the child participant in the present study has diplegia cerebral palsy (section 3.11, page 68).

Cognitive processes

Cognitive processes are mental processes: thinking, attention, memory, language, learning, reasoning, problem solving and decision making, processes dealt with, for example, in cognitive neuroscience theory (for example, Schacter and Moscovitch, 1984) and cognitive psychology (Neisser, 1967).

Attention

The concept of attention is complex with many cognitive processes identified as mechanisms of attention (Burack and Enns, 1997). For example, attention network theory (Posner and Peterson, 1990) proposes neural networks[11] associated with three discrete forms of attention: 'orienting' responsible for visual attention (Berger and Posner, 2000) 'executive' responsible for effortful control of attention (Posner and DiGirolamo, 1998) and 'alerting' for maintaining optimal alert attentional states (Posner and Rothbart, 2007). According to Parasuraman (1998) 'attention' involves the ability to attend to and understand a specific stimulus.

Several authors have elaborated upon the various functions of attention (Dommett, Devonshire and Churches, 2011; Douglas, 1984; Kerns and Mateer, 1996; Mirsky, Anthony, Duncan, Ahearn and Kellam, 1991; Posner and Peterson, 1990; Solberg and Mateer, 1989). Most models include distinct components:

[10] Characterised by spasm.
[11] A proposed system of interconnecting neurons.

- Selective – the ability to maintain attention to a particular thing even in the presence of distractions.
- Alternating–the ability to shift attention focus between tasks.
- Focused–the ability to respond to specific stimuli only.
- Sustained (vigilance)–the ability to maintain attention during continuous and repetitive activity.
- Divided–the highest level of attention, referring to the ability to respond simultaneously to multiple tasks or multiple task demands (Dommett et al., 2011, p.54).

Attention may be considered essential for learning. For success in tasks requiring higher levels of attention (alternating and dividing), lower levels of attention (focusing and sustaining attention) are thought to be necessary (Sohlberg and Mateer, 1989). Of particular relevance to the present study, it is thought that memory functions are dependent on attention and information processing for proper registration of information to be learned (Curran, 2000; Fischler, 1998; Pashler, 1998).

Within a learning environment, children are required to concentrate and sustain attention. 'Sustained attention' refers to the ability to maintain a constant behavioural response over time when involved in a continuous and repetitive activity (Kerns and Mateer, 1996). 'Attentional difficulties' in the present study refers to difficulty in *sustaining* attention.

Memory

Memory has been described within the field of psychology as a range of distinct cognitive processes involved with acquisition, retention and retrieval of information (Greenfield, 1997; Gross and McIlveen, 1999; Tulving, 1991).

Working Memory

Working memory (WM) is conceptualised as a mental workspace where information is stored and manipulated for short periods during complex tasks (Baddeley and Hitch, 1974).

Executive Function

This has been defined as multidimensional, involving a variety of high-level cognitive abilities (De Frias, Dixon and Strauss, 2006) that control and regulate other faculties. To achieve goals, these mental activities are needed for planning, organising, guiding, revising and monitoring behaviour (Messina, Tiedemann, de Andrade and Primi, 2006, p.29). As all processes are thought to be linked it may be difficult to isolate a single executive skill or deficit. Consequently, 'a low score on a test that purports to measure one executive skill could reflect a deficit in a different executive process as well.' (Sparrow, 2012, p.66).

Visual perception

Visual perception is the ability to interpret and give meaning to what is seen. It is the process where information from the environment is interpreted through the senses and organised into meaning.

2.4 Learning difficulties associated with Cerebral Palsy

Although CP is defined as a condition that affects movement and coordination, literature suggests that children with impaired motor skills have an increased risk of disorders of attention or learning (Ewen, Shapiro and Seminar, 2006). Although the reported prevalence of learning difficulties amongst children with CP varies amongst studies (SCOPE, 2014) one in every two is thought to be intellectually impaired (Cerebral Palsy Alliance, 2016). Early studies (Asher and Schonell, 1950; Dunsdon, 1952) noted a relationship between the level of intelligence and degree of disability generally including CP.

Current thinking supports the notion that motor development, cognition and executive functioning are not separate systems (Koziol and Barker, 2013). This is important because some studies suggest children with CP have deficits in executive function *in addition to* motor impairment, as if the two were entirely independent (Helder and Larsen, 2012).

2.5 Current understanding of attentional difficulties in Cerebral Palsy

Unfortunately, given the focus on attention of the present study, no studies could be found isolating attentional difficulties in CP. However, literature considering attention *together with* working memory is reviewed later.

It was reported above that CP can result from a brain injury. This is important because it is thought that attention may be disrupted by brain injuries to the frontal lobes[12] (Ponsford, 1995; Wrightson and Gronwall, 1999) and specifically in the ability to sustain attention (Parasuraman, Warm and See, 1998; Swick and Knight, 1999). Additionally, children at risk of CP resulting from very low birth weight have been found to exhibit difficulties with sustained attention and WM (Luciana, 2003). This is supported by studies undertaken on the motor behaviour of people with spastic diplegic CP, which have pointed to impairment in attention control[13] (Heinen, Kirschner, Fietzek, Glocker, Mall and Korinthenberg, 1999; Leonard, Moritani, Hirschfeld and Forssberg, 1990; Leonard, Sandholdt, McMillan and Queen, 2006; Vry, Linder-Lucht, Berweck, Bonati, Hodapp, Uhl and Mall, 2008) and impairment in cognitive performance (Bottcher, Flachs and Uldall, 2010; Christ, White, Brunstrom and Abrams, 2003; White and Christ, 2005). Kolk and Talvik (2000) suggest that *sustained* attention and inhibitory control[14] are significantly more impaired in children with right hemisphere lesions[15]. Earlier work by Korkman and Von Wendt (1995) found that in left hemisphere lesions, *focused* attention seemed more susceptible to impairment. As a practitioner, this is useful in informing my understanding of likely attentional difficulties in children with left and right-side hemiplegia. However, a rounded picture of the child is necessary to ensure all factors that may affect learning are considered. For example, delayed learning may be due to decreased participation in daily activities (Ostensjo, Carlberg, and Vollestad, 2003) *resulting* from motor impairment and coordination difficulties rather than a specific impairment of cognition. For example, social interaction is of fundamental importance in the development of cognition in Vygotsky's theories (Vygotsky, 1978).

[12] Located at the front of the brain.
[13] An individual's capacity to choose what they pay attention to and what they ignore.
[14] A cognitive process that permits an individual to inhibit their impulses and natural, habitual, or dominant behavioural responses to stimuli.
[15] An abnormality seen on the right side of the brain.

2.6 Memory difficulties in Cerebral Palsy

A review of literature on working memory difficulties has been included because, as stated above, WM and attention are not often considered independently in the CP literature. Central to the present study is the idea that good WM is essential to almost all cognitive abilities that children acquire.

Within the general population, children with cognitive impairment are thought to experience difficulties in situations requiring WM (Henry and Gudjonsson, 2003). Deficits in WM are thought to be a factor in poor academic progress (Alloway, Rajendran and Archibald, 2009) and learning difficulties (Kofler, Rapport, Bolden, Sarver and Raiker, 2010; Kofler, Rapport, Bolden, Sarver, Raiker and Alderson, 2011; Gathercole, Pickering, Knight and Stegmann, 2004). This is important to my advisory role because advice that has relevance to other children within the class is more likely to be embedded in practice than strategies for one child.

WM deficits in children with CP are thought to be related to disorders of the development of movement, posture and coordination (Bax, Goldstein, Rosenbaum, Leviton, Paneth and Dan, 2005; Jenks, van Lieshout and de Moor, 2009; Straub and Obrzut, 2009). This is consistent with views presented earlier regarding the interconnectedness of motor development, cognition and executive function. A difficulty within the literature on children with CP concerns inconsistent study findings (Helder and Larsen, 2012). For example, Kolk and Talvik (2000) tested memory span[16] in children identified as having spastic hemiplegia and in typically developing age-matched children and found significantly worse performance in the clinical group. Earlier using a word-span task[17], White, Craft, Hale and Park (1994, 1995) compared the children's performance to that of a group of typically developing children but did not find differences in working memory.

2.7 The relationship between working memory and attention

The discussion, so far, has established a probable link between impaired motor skills, difficulties with attention and WM and increased risk of disorders of

[16] The longest list of items that a person can repeat back in correct order immediately after presentation.
[17] Word-span tests are a measure of the ability to recall a list of words in order.

learning (for example, Alloway, Rajendran and Archibald, 2009) which may remain undetected (Ewen et al., 2006).

Howieson and Lezak (2004) note the difficulties in distinguishing between a memory disorder and a general impairment in attention or concentration which disrupts memory. Another complication arises from the possibility that poor processing speeds[18] may present as memory difficulties. Howieson and Lezak (2004) suggest that to ascertain the nature of components of complex disorders, observation of the relationship between performance on memory tests and other cognitive tests can be beneficial. Middleton (2004) echoes this, stating that distractibility, poor focus and reduced attention span can affect memory test scores. Therefore, problems which may present as memory deficits may be a result of attentional difficulties. Additionally, children who present with poor visuospatial memory may have perceptual organisation[19] problems (Middleton, 2004). It is accepted that attention and WM are indispensable to higher order cognitive skills such as problem solving and the creation of new knowledge (Anderson and Doyle, 2004). Memory functions are thought to be dependent upon both attention and the ability to extract meaning from a stimulus, to support learning (Curran, 2000; Fischler, 1998; Pashler, 1998), therefore, reductions in these capacities are likely to impact on memory.

Whilst emphasis on the allocation of WM resources is considered by many theorists to relate to processing and storage activities (Hitch, Towse, and Hutton, 2001) others consider memory capacity is about controlled, sustained attention when distractions are present (Conway and Engle, 1996). Based upon this premise, loss of information from WM principally results from disruption to attention (Nelson and Goodmon, 2003). In view of that, WM performance is dependent upon retaining focus during tasks rather than on short-term span or efficient processing (Hasher and Zachs, 1988).

2.8 Assessment of attention and working memory difficulties in children

The following provides an overview of some of the tests that are available for use with children. Since attentional difficulties may affect memory performance, both are generally assessed in cognitive testing. Researchers using such tests

[18] The pace at which you take in information, make sense of it and begin to respond.
[19] How we see and experience the world.

to assess attention (for example, dichotic listening[20], TEAch[21], NEPSY[22]) have found that children with hemiplegia have difficulty moving their focus from one thing to another (attentional shifting) and have also found deficits in divided and sustained attention (Bottcher, 2010).

Gathercole and Pickering (2000) carried out a study to investigate WM in relation to academic achievement in typically developing children. The participants consisted of eighty-three children aged 6 and 7 years attending mainstream schools. A test battery was designed to assess WM components, based on Baddeley and Hitch's (1974) model. Tests included forward digit recall and recognition and recall of words and non-words. On the basis of their performance in English and Mathematics, children were assigned to normal or low achievement groups. Impairments in both central executive function and visuo-spatial[23] memory were noticeable in the low attainment group. Findings indicated that academic progress is linked to working memory skills for this age group. Therefore, assessment of working memory may be considered useful for children at risk of making poor academic progress (Gathercole and Pickering, 2000).

It has been established that WM problems are linked to poor academic progress and inattentiveness (Alloway, Gathercole, Kirkwood and Elliott, 2009; Gathercole, Alloway, Kirkwood and Elliott, 2008). Although there are a number of published psychological assessments available to assess both memory and attention, they are generally only available to licensed practitioners, such as Educational or Clinical Psychologists. At present, recruitment and retention of Educational Psychologists (EPs) is problematic nationally and limited resources are predominantly focused on statutory work. Consequently, schools require alternatives to traditional methods of assessment and reliance on external professionals in order to understand the nature of cognitive difficulties.

[20] A psychological test commonly used to investigate selective attention within the auditory system.
[21] The Test of Everyday Attention for Children (Manly, Robertson and Nimmo-Smith, 1998) measures selective attention, sustained attention and attentional switching.
[22] A series of neuropsychological tests. (Korkman, Kirk and Kemp, 1998).
[23] Processes that involve visual and spatial awareness and retention of material.

Tests of WM and sustained attention

As outlined above, a number of psychological tests, which deal with memory span, are not accessible for use by teachers as they are licensed to be administered by psychologists. For example, the Digit Span tests from the Wechsler Intelligence Scales (WIS) (Wechsler,1955,1981,1997) and the Wechsler Memory Scales (WMS) (Wechsler, 1945,1987,1997). A further difficulty arises from the notion that poor performance on simple digit span tasks is more likely to demonstrate attentional difficulties rather than memory impairment (Howieson and Lezak, 2004). Although problems with short-term memory exist, they are comparatively rare (Vallar and Shallice, 1990; Warrington and Shallice, 1984).

Tests of sustained attention include the Wechsler Memory Scales, Mental Control tests, and Subtracting Sevens (Strub and Black, 2000) and the continuous performance test (Connors, 2014) which measures sustained attention over 14 minutes. The Test of Everyday Attention provides an assessment of attentional demands of common tasks (Crawford, Sommerville and Robertson, 1997; Robertson, Ward, Ridgeway and Nimmo-Smith, 1996). As these are also specialist tests administered by psychologists it was not possible to use them to test Bob's attentional ability. A tool that could be used by classroom practitioners was therefore needed to identify possible difficulties of WM and attention.

In view of the issues highlighted, Middleton (2004) draws attention to the importance of qualitative assessment and observation of children undertaking different tasks, in order to evaluate the types of problems they encounter. The strength of the single-case study approach taken in the present study provided opportunities to observe the extent of Bob's ability to attend across a range of activities within the domain of mathematics.

Within my role as advisory teacher I trialled the Working Memory Rating Scale (WMRS) (Alloway, Gathercole and Kirkwood, 2008) and Automated Working Memory Assessment (AWMA), (Alloway, 2007) with the five children cited in the introductory chapter. They were pivotal in raising my awareness of some of the difficulties for this cohort of children. The WMRS is currently the only commercially observer-based behavioural rating scale available for teachers. It

is designed for specific use by classroom practitioners to identify behaviours that could indicate possible WM deficits.

The Automated Working Memory Assessment (AWMA), (Alloway, 2007) which can also be administered by teachers, is a PC-based assessment of WM skills. An advantage is that minimal training is required as the administration and scoring is fully automated and an interpretation of how WM scores will affect learning is provided. My experience of using both these assessments within my advisory role raised concerns regarding their suitability with children with CP. This was because although the WMRS was validated by the authors with the AWMA, discrepancies between the results of these were apparent when I used them with five children with CP. For example, the AWMA would indicate difficulties in some components of WM which were not reflected in the WMRS. Practitioner reflection suggested that other factors associated with their physical impairment could also influence the results. For example, not listening to and remembering information could result from episodes of distractibility caused by muscular pain and discomfort. The combination of psychosocial problems combined with fatigue could therefore be the root of problems rather than specific cognitive difficulties. Therefore, it was necessary to find a means of identifying difficulties a) that took these factors into account and b) that teachers could have confidence in using for children with CP.

In addition to the WM tools, within my role as advisory teacher, I trialled the use of a published attention test with the aforementioned five children with CP. This was the only published tool available for this age group that I could use as a teacher. This tool was modelled on the Attention Process Training program (Sohlberg and Mateer, 1987) used successfully in adult populations. However, a number of issues arose and so constituted problems with administration. For example, on completion of each task I provided verbal feedback and praise such as, 'I was pleased to see you were checking very carefully before telling me you had finished, that is a really good thing to do.' Subsequently, the children often took longer to complete the tasks to demonstrate the praised 'skills'. This meant that they were sustaining attention for longer periods but because of the increased time taken, improvement was not reflected in their scores.

The difficulties encountered with the reliability and administration of these tools highlighted the need for a different approach that could be used to assess cognition in children with CP.

2.9 Studies undertaken in atypical populations

The following study undertaken by Alloway, Rajendran and Archibald (2009) is highly relevant to the present study. Firstly, although participants were not children with CP, children with developmental disorders[24] were included and secondly, because the assessment of working memory was undertaken using the AWMA (Alloway, 2007). This was the tool I trialled within my role as advisory teacher discussed above.

Participants comprised 163 children with developmental disorders. 55 of the children had a diagnosis of Developmental Coordination Disorder (DCD), a condition which affects both movement and perception (Visser, 2003). This group consisted of 80% boys with a mean age of 8.8 years, attending mainstream schools. In terms of gender, age and movement difficulties, parallels can be drawn to the present study. The aim of this study was to investigate whether a specific diagnosis impacts upon memory skills. Participants included children with a Specific Language Impairment[25], Developmental Coordination Disorder[26], Attention-Deficit Hyperactivity Disorder[27], and Asperger syndrome[28]. Findings of this study suggested that all groups appeared to have working memory deficits.

Following on, and of relevance to the present study, evidence indicates that children with motor impairments have a specific deficit in visuospatial short-term and working memory, which were not found in children with general learning difficulties (Alloway and Temple, 2007) or specific language impairments (Archibald and Alloway, 2008). For example, a study which compared the

[24] A group of psychiatric conditions originating in childhood that involve serious impairment in different areas.
[25] Difficulties with oral language.
[26] A motor skills disorder.
[27] A mental disorder characterised by hyperactivity, impulsiveness and attentional problems.
[28] A developmental disorder characterized by difficulties in social interaction, nonverbal communication and restricted and repetitive patterns of behaviour and interests.

working memory profiles in children with ADHD[29] and DCD[30] (Alloway, 2011) showed that the group of children with attention problems (ADHD) demonstrated impairment in verbal and visuospatial working memory but scores in short-term memory tasks were typical for their age. Memory problems were thought to relate to abnormalities associated with ADHD rather than general neurodevelopmental delay (Frith and Happé, 1998). Consequently, verbal memory impairments may be more prevalent in children with language related disorders, deficits in visuospatial memory more notable in children with motor difficulties. This was an important consideration in planning the intervention for Bob because the nature of activities necessitated processing visuo-spatial[31] information. Whilst I queried the reliability of the AWMA (appendix one, page 244) results indicated Bob had average performance for his age group in that component of WM.

A study undertaken by Barca, Frascarelli and Pezzulo (2012) is of particular interest to the present study. Firstly, it was a single case-study with a child with CP and secondly, the purpose was to investigate the child's visuospatial working memory and visual imagery. The Raven's Coloured Progressive Matrices, (Raven and Raven, 1986) was used because in other studies it was shown to be a valid test of cognitive functioning in CP (Barca, Pezzulo and Castelli, 2010; Pueyo, Junquè, Vendrell, Narberhaus and Segarra, 2008a). The test involves presenting visual patterns in increasing difficulty. Visuoperceptual[32] impairments were identified using the Developmental Test of Visual Perception (Hammill, Pearson and Voress, 1994). The test comprises eight subtests: shapes constancy, Figure ground, Visual Closure and Position in space (visual perceptual skills) and Copy, Spatial relationship, Visual motor speed, Eye Hand Coordination (visual-motor integration). Results suggested that children with CP may have problems with tasks that involve visuospatial working memory due to difficulties encoding visual and spatial information and in creating mental representations.

[29] Attention deficit hyperactivity disorder (ADHD) is a behavioural disorder that includes symptoms such as inattentiveness, hyperactivity and impulsiveness.
[30] Developmental coordination disorder (DCD) is a common disorder affecting fine and/or gross motor coordination in children and adults.
[31] Visual perception of the spatial relationships of objects
[32] Recognition of objects

To take account of this possible problem a range of different practical resources were included in the intervention. During the intervention, my practitioner reflections questioned Bob's ability to interpret three rows of information when specifically using two-dimensional shapes. As a result, the re-planning of some activities focused on the presentation of three-dimensional resources and patterns arranged in a single row, always starting from Bob's left side as culturally this is how children are taught to scan and track words when reading.

2.10 Mathematical difficulties in children with Cerebral Palsy

As the present study applied a mathematical intervention based around pattern, a brief overview of literature examining mathematical difficulties in children with CP is included.

Poor WM has been highlighted as a fundamental cause of mathematical deficits amongst all children (for example, Geary, Hoard, Nugent and Byrd-Craven, 2007; Hitch, 1978; Swanson and Sachse-Lee, 2001). It has been argued that mental arithmetic[33], problem solving and multi-step procedures are all affected (DfE, 2012) because in all these operations, data must be stored whilst new information is processed (Raghubar, Barnes and Hecht, 2010).

Research suggests that for children experiencing difficulties with arithmetic, working memory may be a factor. These difficulties seem more widespread amongst children with CP than in the mainstream population (Jenks, van Lieshout and de Moor, 2009). WM is considered a significant influence on the development of number skills (Geary, Hamson and Hoard, 2000; Hecht, Torgesen, Wagner and Rashotte, 2001; Noël, 2005; Stock, Desoete and Roeyers, 2009). In the general population, children experiencing difficulties with mathematics have been found to have deficits in WM (Siegel and Ryan, 1989). Clearly this will be exacerbated by poor sustained attention during tasks involving multiple stages such as mental mathematics.

Success in early arithmetic is dependent upon early numeracy[34] understanding (Desoete and Grégoire, 2006; Krajewski and Schneider, 2009) including skills in: counting abilities, numeral estimations, and logical operations (Desoete and

[33] Carried out in the mind without any physical action or the use of any physical aid.
[34] The ability to reason and to apply simple numerical concepts.

Grégoire, 2006; Passolunghi, Vercelloni and Schadee, 2007). Skills such as counting and number recognition influence later academic achievement (Duncan, Dowsett, Claessens, Magnuson, Huston and Klebanov, 2007; Claessens, Duncan and Engel, 2009; Byrnes and Wasik, 2009; Locuniak and Jordan, 2008). A longitudinal study carried out by Jenks, Lieshout, Ernest and Moor, (2007) looked at the development of arithmetic in children with CP and compared this to a control group of children in mainstream education without CP. Assessment consisted of addition and subtraction calculations and response times were recorded for accuracy and speed. Tests were administered at four points over a two-year period for each child (middle and end of each year). Results corresponded with other studies (Jordan, Hanich and Kaplan, 2003) which indicated a relationship between arithmetic skill and nonverbal intelligence[35]. An average response time of 10 seconds, for retrieval of facts, was recorded at the end of the second year for the group with CP. This compares to a response time of 2 seconds for children without CP. This suggests facts are not being retrieved from long-term memory and problems are being solved by counting. The study also demonstrated that increased severity of impairment in the left hand decreased addition and subtraction speed. This is relevant to the present study as an analysis of changes in motor actions across the intervention was undertaken. The purpose was to establish if motor actions on the more affected right-side increased as a result of repetition of some of the practical activities (section 5.2, page 116.)

Other research indicates a higher prevalence of arithmetic learning problems in children with CP and motor difficulties (for example, Frampton, Yude and Goodman, 1998; Son and Meisels, 2006). A possible reason could be that physical impairment restricts required motor experiences (Van Rooijen, Verhoeven and Steenbergen, 2011). For example, in children with CP, delayed counting and difficulties evaluating quantity have been linked to eye-hand coordination (Arp and Fagard, 2001). This is important because it has been proposed that number processing and physical movement (for example, grasping) are linked (see Moretto and di Pellegrino, 2008). This is relevant for children with CP as acquisition of skills may be compromised by motor

[35] The ability to make sense of and act on the world without necessarily using words

impairment, rather than by WM or attentional difficulties. To address possible problems arising from coordination difficulties in the present study a typography of movement was designed by the researcher and is described in Chapter 4 (section 4.4, page 92).

2.11 Rationale for the focus on 'pattern' in the present study

The review so far has suggested that children with CP may have specific problems with arithmetic (Jenks et al., 2007). Studies have demonstrated that children with CP are frequently delayed in counting, subitizing and simple arithmetic operations when compared with typically developing peers (Van Rooijen, Verhoeven and Steenbergen, 2011). In view of that, an intervention which avoided arithmetic was designed. The idea of 'pattern' was the principal concept chosen because as well as being central to mathematical understanding (Ferrini-Mundy, Lappan and Phillips, 1997; Lee, 1996; Mason, 1996) it provided scope to utilise concrete resources and visual presentations. Thus, by minimising WM demands a focus on sustained attention was anticipated. For the purpose of the present study, pattern is defined as a repeated design or recurring sequence of shapes or other objects, arranged according to a rule.

Pattern was chosen because the capacity to recognize a pattern is considered a precursor to the ability to generalize and abstract (Burton, 1982; Threlfall, 1999) and provides a concrete and familiar experience (Threlfall, 1999). Children first engage with repeating patterns in a linear arrangement, with a unit that repeats (ABABAB; National Association for the Education of Young Children, 2014; National Council of Teachers of Mathematics, 2007). Units typically contain two or three elements (AB, ABB, ABC) and contain an element that varies: colour, shape, size. This informed the planning of the intervention in the present study where simple ABAB patterns underpinned the activities.

Furthermore, knowledge of repeating patterning has been linked to mathematics achievement. This is important because the choice of mathematics as a domain in the present study arose from practitioner concerns which were discussed previously (section 1.4, page 20). In a longitudinal sample, the ability to repeat a pattern at the end of pre-school was a single

predictor of mathematics achievement at the end of primary school (Miller, Rittle-Johnson, Loehr and Fyfe, 2016). Patterning and algebra have been incorporated into early learning in many countries (for example, Greenes, Cavanagh, Dacey, Findell and Small, 2001; National Council of Teachers of Mathematics (NCTM), 2000; Ontario Ministry of Education and Training (OMET), 2003, 2005; Warren, 2000). Patterns provide a concrete way for children to explore abstraction and generalisations (Blanton and Kaput, 2004; Carraher, Schlieman, Brzuella and Enrnest, 2006; Cuevas and Yeatts, 2001; English and Warren, 1998; Greenes et al., 2001; National Council of Teachers of Mathematics (NCTM), 2000). The importance of pattern is being increasingly recognised in early mathematics (Kidd, Pasnak, Gadzichowski, Gallington, McKnight, Boyer and Carlson, 2014; Rittle-Johnson, Fyfe, Hofer and Farran, 2016; Warren and Cooper, 2008) and informed the subsidiary research question of the present study:

- What approach is needed to develop early mathematical understanding for a child with CP?

Although the literature search did not provide evidence of pattern being used to measure sustained attentional control in previous studies, it was thought appropriate because once the structure of a pattern has been understood, ability to attend to the task becomes the most important factor in its successful completion (Geary, 2013). The present study provided an opportunity to explore this concept by removing the cognitive demands of *numerical* patterns from activities when it became evident these were problematic for Bob.

2.12 Other factors that can affect learning in children with CP

The literature reviewed so far has provided accounts of possible difficulties in children with CP and highlighted a number of problems in isolating the causes. The search provided greater insights on WM difficulties but also highlighted the limited studies undertaken to inform attentional difficulties in children with CP. However, it is important for practitioners to consider other factors which may be the cause of, or contribute to, learning difficulties in children with CP. Accordingly, an overview and discussion of some of these follows. The purpose is to highlight factors which may create barriers within a learning context, including the impact of associated medical conditions in CP and the emotional

aspects of coping with disability, thus broadening and enriching the understanding generated by the close focus on attention.

2.13 Associated medical difficulties which may disrupt learning

Medical/biological difficulties may include some or all of the following: constipation, muscle spasms, problems with sleeping, sensory impairment (hearing and visual acuity), speech and language, feeding difficulties, epilepsy, spatial awareness and difficulties with visual perception and behavioural problems, such as inattention and anxiety (Lynch, 2013).

Epilepsy[36]

Whilst Bob did not have a diagnosis of epilepsy concerns had been raised by school-based staff of observed episodes whereby he appeared to be 'zoning out'. These may have been indicative of absence seizures[37]. This is an important factor to consider as epilepsy is thought to cause problems with learning and memory (Hermann, Dabbs, Becker, Jones, Myers, Gutierrez, Wendt, Koehn, Sheth and Seidenberg, 2010). In addition, seizures[38]are a recognised medical problem in spastic CP (Singhi, Jagirdar, Khandelwal and Malhi, 2003; Wichers, Odding, Stam and Van Nieuwenhuizen, 2005) which is the type Bob has. Several studies suggest co-occurrence between epilepsy and lowered cognitive functioning in children with spastic CP (Cioni, Sales, Paolicelli, Petacchi, Scusa and Canapicchi, 1999; Kolk and Talvik, 2000; Sigurdardottir, Eiriksdottir, Gunnarsdottir, Meintema, Arnadottir and Vik,2008; Singhi et al., 2003; Vargha-Khadem, Isaacs, Vanderwerf, Robb and Wilson, 1992). In addition, there may be other associated conditions including anxiety, depression, and attentional difficulties (Young Epilepsy, 2015). Therefore, the ability to learn, which is maximised by being in either ‘quiet’ or ‘active alert’ bio-behavioural states (Simeonsson,1988; Nicholas, 2000), may be continuously interrupted by ongoing epileptic episodes. Of relevance to the present study, findings by Kolk and Talvik (2000) suggest that seizures were shown to be a predictor of difficulties in focused and sustained attention. To support this, a study undertaken with children with hemiplegic CP showed scores below the

[36] A brain disorder that causes people to have seizures.
[37] A type of seizure causing lapses in awareness, sometimes with staring. (These were reported to parents and were being monitored).
[38] Uncontrolled electrical activity in the brain, which may produce a physical convulsion.

age-matched control group in tests of sustained attention (Bottcher, 2010). From this literature it seemed possible that Bob could be at increased risk of difficulties with focused and sustained attention. The intervention was therefore an important means of establishing if attentional control could be trained and improved in a child with CP.

Speech and Language difficulties

A study undertaken with children with spastic diplegia CP to measure processing of speech sounds and comprehension reported a high proportion of normal verbal skills (Pirila, van der Meere, Korhonen, Ruusu-Niemi, Kyntaja and Nieminen, 2004). These findings have been echoed in other language-specific studies which noted average scores in verbal intelligence[39] coupled with lower scores in perceptual organization and processing speed (Goodman and Yude, 1996; Sigurdardottir et al., 2008). However, some studies have suggested impairments in verbal fluency and comprehension in children with spastic hemiplegia (Kolk and Talvik,2000). These findings have not, however, been replicated in other studies (Korkman and Von Wendt, 1995; Krageloh-Mann, 2004). It has been suggested that children with speech impairments relating to oral-motor difficulties in CP, are at risk of experiencing literacy-related problems (Peeters, Verhoeven, de Moor and van Balkom, 2009) including detecting rhyme, segmenting syllables and phonemes (Card and Dodd, 2006). Studies carried out in the 1950s noted that incidence of auditory impairments caused subsequent language development to be delayed or restricted in children with CP (Dunsdon, 1952; Fisch, 1955; Porter, 1957).

The findings provide useful insights for practitioners working with children with CP. However, currently there are high thresholds (and severity of symptoms) for accessing Speech and Language Therapists. This can result in an incomplete picture of language difficulties in children with CP. Therefore, although a child may present with good conversational skills, there may be underlying difficulties in understanding the formal vocabulary of school. This provides an example of the complexity of interrelated factors.

[39] A measurement of ability to use language to analyse and solve problems.

Visual deficits

Difficulties in visuoperceptual and visuoconstructive[40]functions have been established in children diagnosed with spastic CP (Abercrombie, 1964; Nielsen, 1962). Courbis, Coello Bouchart (2004) also reference the high level of visual deficits in people with CP, including field of vision and eye movement disorders (Black, 1980) and visual-perceptual disorders (Breakley, Wilson, and Wilson, 1974). Visuoperceptual and visuoconstructive functions refer to information perceived through the eyes which enables interpretation of the surrounding environment. From discussions I had with the occupational therapist involved with Bob at the time of the present study, visual perceptual concerns had not been raised. Occupational therapists are qualified to undertake tests of visual-perception but without this assessment educational practitioners may be unaware of difficulties and implications for the child. This was an important consideration because studies have found a high incidence of visual defects in children with CP. In addition, difficulty in spatial perception may affect the development of hand and eye co-ordination and be a factor in spatial discrimination[41], which is generally below average in children with CP (Dunsdon, 1961).

Social, emotional and behavioural difficulties

For children with CP, the frequency of opportunities for social interaction, which is important in learning, may be limited by physical impairment and dependence upon adults to meet their access needs. Therefore, mobility and other underlying factors that may affect learning are considered next.

Literature focused on the social development of children with CP is limited (Warschausky, Argento, Hurvitz and Berg, 2003). However, some more recent studies have highlighted difficulties with peer relationships and social rejection (Spincola, Moore, Allegrante, Palma, Lewin and Carlson, 2010). Difficulties in maintaining successful peer relationships has been attributed to anxiety relating to fitting in at school, especially as many children are periodically withdrawn for specialist support (Olsen and Sutton, 1998). Social problems may be exacerbated by poor motor control (Heward, 2006) and the pressures of coping

[40] The ability to organize and manually manipulate spatial information to make a design.
[41] Ability to detect differences in spatial location.

with disability (Boeraerts and Roeder, 1999). For example, concerns around appearance have been cited as a factor in depression and social problems (Sexson and Dingle, 2001). It has been reported that social and emotional problems affect between 30 - 80% of children with CP (McDermott, Nagle, Wright, Swann, Leonhardt and Wuori, 2002) including poor social skills (Lavigne and Faier-Routman, 1993) and internalising problems (Hinton, Nereo, Fee and Cyrulnik, 2006). Goodman and Graham (1996) suggest that many children with hemiplegia have significant emotional or behavioural difficulties which are unacknowledged and a study carried out by Lepage, Noreau, Bernard and Fougeyrollas, (1998) noted difficulties in integration and relationships in children with mild hemiplegia.

Bottcher (2010) reviewed studies of children with spastic CP which investigated different aspects of their cognitive functioning in relation to social participation but difficulties were not accredited solely to motor impairment (Michelsen, ldall, Kejs and Madsen, 2005). For instance, a study carried out by Martlew and Cooksey (1989) charted the behaviour of a child with CP in his nursery setting over a two-year period. They noted reduced interactions by comparison with those of his younger sister. This was attributed to his physical disability and poor expressive language skills.

A study carried out in Jordan, investigating behavioural difficulties in 96 children with CP, concluded that they experienced moderate levels of behavioural problems. These included: shyness, depression, anxiety, social isolation and aggression (Kholoud and Dababneh, 2013). It has been suggested that a child's perception of their competence can affect feelings of self-worth which can influence behaviours, including motivation (Harter, 1985, 1999; Ryan and Deci, 2000). Kramer and Hammel (2011) propose therefore, that self-perceptions about ability may be important factors in learning and development. In a study to understand the processes involved in developing competence, Kramer and Hammel (2011) set up problem-solving activities relevant to the children's daily lives and impairment. The study drew on ecological theories of development[42] by matching the child's needs and abilities to the environment.

[42] The role of different environmental systems in the development of social behaviour and attitudes.

This is relevant because environments which support the individual are thought to promote development and learning (Bronfenbrenner, 2005).

Several studies (Conners and Stalker, 2007; Curtin and Clarke, 2005; Davis and Watson, 2002; Priestley, Corker, and Watson, 1999) have suggested that rather than concentrating on impairment, children with disabilities attend to similarities with peers and focus on their personal strengths and abilities. Such studies may therefore provide insights into how children with disabilities construct competence (Kramer and Hammel, 2011).

The literature reviewed so far demonstrates how different studies have disagreed about the nature of difficulties for children with CP. Due to the sparse number of educational studies undertaken specifically with children with CP, a clear picture of the nature of difficulties has not been drawn. However, what has emerged clearly is the possibility of a number of differing factors. These can be complicated to identify from a teacher's perspective due to the clinical expertise needed to administer the appropriate assessments by a team of multi-professionals, including health professionals. Current deficiencies in funding in England mean that access to professionals can be problematic and underlying conditions consequently be undetected and undiagnosed. This literature review now considers the perspectives of present-day practitioners working with children with CP.

2.14 What perspectives and insights do present-day practitioners have?

In this practitioner-based research, I have included a range of professional observation and opinions, so as to create a richer context for the research questions than can be provided by the academic literature alone.

This section summarises information from reports written by specialist teachers within the researcher's team. Children were identified by going through cases with teachers and highlighting those with a medical diagnosis of CP. Reports were written for different purposes, including initial assessment, visit records and advice and guidance for statutory annual reviews for children with an Education Health and Care Plan. The reports include information about observations undertaken across a range of different subjects and the views of the children, parents and/or school staff when gained. The reports are typically

written biannually and provide a picture of the child's functional skills which are professionally guided and draw on differing perspectives. They are considered to be a valuable and credible source of up-to-date information by the Local Authority. Reports written by specialist teachers, for a total of 38 children with CP were analysed. A total of 18 had a diagnosis of spastic diplegia; this is presented in more detail separately because Bob has this type of CP. An overview of difficulties reported for the children with hemiplegia, diplegia and quadriplegia is presented in Table 2.1. The table reveals that common to all the children with CP and therefore relevant to Bob, are difficulties with fine and gross motor skills, attention, memory and social and emotional problems.

Table 2.1: Difficulties cited in specialist teacher reports for children with Cerebral Palsy

Difficulties	**Right-side Hemiplegia[1]**	**Left-side Hemiplegia[2]**	**Diplegia[3]**	**Quadriplegia[4]**
Physical				
Fine motor	**Y**[5]	**Y**	**Y**	**Y**
Gross motor	**Y**	**Y**	**Y**	**Y**
Spatial awareness	Y	Y	N[6]	N
Visual perceptual	Y	N	Y	Y
Fatigue	Y	N	Y	Y
Other medical	N	N	Y	N
Speech/language	N	Y	Y	Y
Cognitive				
Memory problems	**Y**	**Y**	**Y**	**Y**
Attention	**Y**	**Y**	**Y**	**Y**
Curriculum				
Mathematics	N	Y	Y	Y
Literacy	N	Y	Y	Y
Other				
Independence	Y	N	N	Y
Organisational skills	Y	N	N	N
Social-emotional	Y	Y	Y	Y

Notes:
Right-side Hemiplegia[1] 3 children reviewed
Left-side Hemiplegia[2] 4 children reviewed
Diplegia[3] 21 children reviewed
Quadriplegia[4] 13 children reviewed
Y[5] Difficulties cited in reports
N[6] Difficulties not cited in reports

Difficulties highlighted, for children with CP spastic diplegia[43] by the specialist teachers in their reports included:

- Cognitive: attention and memory
- Curriculum: mathematics, literacy
- Motor: gross and fine motor skills
- Medical: fatigue, pain, epilepsy, poor sleep
- Sensory: visual perception, visual-spatial

[43] Bob's diagnosis.

- Social-emotional: peer relationships and interaction, play skills, frustration, anger, social isolation, awareness of disability and difference.

Although the literature specifically considering spastic diplegia was limited, observations by specialist teachers did not provide any evidence of language difficulties, and this was in line with the published findings.

2.15 The importance of the present study

The literature highlights the complexity of hidden difficulties faced by many children with CP which extend beyond visible motor impairment. In addition to motor impairment children may be experiencing mental health issues arising from disability, which have not been identified. For example, there is a growing recognition amongst health professionals of increased anxiety relating to hemiplegia CP. The combination of physical, cognitive and mental concerns outlined may impact on a child's capacity to access learning. To compound these difficulties children with problems that are perceived to be behavioural in nature may be subject to inappropriate sanctions in the classroom. A further problem stems from the additional energy and effort required from the child and resulting fatigue from undertaking motor tasks. It has been my practitioner experience that if this has not been understood and fully appreciated, the children are described as lazy.

2.16 Summary

This chapter has provided a review of work which has been done in the field of educational studies with children with CP, surveying both conceptual and professional aspects. A range of difficulties associated with CP has been identified in the literature, although there is some disagreement among studies which have sought to identify these.

CP is an umbrella term for a number of neurological conditions that affect movement and co-ordination; however, almost half of children with CP are thought to have a cognitive impairment as well. Associated medical difficulties, such as epilepsy, are thought to impact upon memory and learning. Findings from studies which considered language functioning were mixed. For example, the extent of proposed impairments in verbal fluency and comprehension differed between studies. Visual deficits, including visuo-perceptual and visuo-

constructive deficits, seem common in spastic CP. A range of social, emotional and behavioural difficulties were identified in the literature. Problems forming successful peer relationships were attributed to various factors, including anxiety, worries about appearance and fitting in, causing depression. Other reasons included decreased opportunities for participation in daily activities due to motor impairment.

Successful task performance necessitates high levels of attention which develop from the acquisition of focused and sustained attention. Attention is an important factor in memory because limitations on memory can result from reductions in either attention or information processing (Marois and Ivanoff, 2005). Attentional skills are thought to be essential for WM but isolating a single deficit through assessments may be unreliable. The present study explores the attentional difficulties of a child with CP because literature suggests memory functions are dependent on attention.

2.17 Plan of the remainder of the thesis

Chapter 3 provides an account of the general method and design of the study and rationale for a single-case design. Chapter 4 provides full information about the participant, Bob, including his case history and various appraisals of his abilities by practitioners and others. It also reports an important pre-intervention observation of his physical movements and of his awareness of pattern, and an appraisal of his elementary number skills. All of these informed planning of the intervention. A schedule of on-task and off-task behaviours, based on the same observations and used as an index of attention, is also presented. Chapter 5 presents details of the intervention. Bob's performance on the intervention tasks was not assessed. Instead, their effect was assessed by two post-intervention assessments separated by a period of time. Chapter 6 presents the initial post-intervention assessment results. Chapter 7 presents the post-intervention assessment results. Chapter 8 provides a comparison of the results of all assessments to determine if engagement, measured by time on-task, improved across the intervention. Finally, Chapter 9, the Discussion chapter, addresses key aspects of the results, their interpretation, and implications for the education of children with CP and for future research.

Chapter 3: Method

3.1 Introduction

In this Method chapter, I describe the methodology and design of the present study and its rationale as a piece of action research. I begin by comparing the theoretical advantages and disadvantages of action research and case study research to answering my research questions.

3.2 Advantages and disadvantages of action research and single-case study (SC) approach in answering the research questions of the present study

Seminal developers of the theory of action research, Argyris and Schön (1991 p.86, quoted in Blichfeldt and Anderson, 2006) and Elliot (1991, p.49) state that "action research takes its cues - its questions, puzzles, and problems - from the perceptions of practitioners within particular, local practice contexts" and "the fundamental aim of action research is to improve practice".

If it is to help improve practice in schools, action research must be conducted under the conditions of everyday life in school. It must fit in with, for example, the school ethos, the conditions in which teachers and other classroom workers operate, and the way they understand their roles. It must also take into account the individual needs of its student participants (Altrichter, Posch and Somekh, 2000). It follows that adaptations to an initial research plan may need to be made *in the course of research* if the context or the needs of participants turn out to require it. It is thus a *dynamic* methodology. In action research, the experimental ideal of the detached observer is modified to some extent, since the researcher's professional insight arising out of involvement with the setting and participants is essential to the design and execution of the study and to interpretation of its results. 'Strategy' and 'reflection' (Altrichter et al., 2000) are terms that characterise the quality of thoughtfulness and responsiveness to context required of the researcher during the process of action research. The present study is a piece of action research.

The advantages of action research in answering the research questions

1. Can the attentional capacity of a child with CP be improved?
2. What approach is needed to develop early mathematical understanding for a child with CP?

lie in the specific relevance to Bob's educators *in their own context* of the results of the enquiry, and the encouragement it gives them to develop and generalise, as far as possible, any demonstrated gains. In the methodological debate, the context-bound nature of action research would be seen from a classical experimental perspective as a disadvantage.

Single case studies[44] (SC), used in clinical, psychological, and also in Special Educational research, are nearer to classical experimental design. Some features of single case studies are used in the present study. These are found in the so-called ABA withdrawal design (also known as ABAB (reversal) design).

In SC, as in classical experimental design, researchers strive for ideally rigorous control of independent variables. But because in medicine and in Special Education, it is often indispensable to know the effect of an intervention *on a specific individual*, experimental norms regarding sample size and the use of control groups are often not possible. Instead, a repeated measures design is used, so that a participant serves as his or her own control. Thus,

> In SC studies, measurements of outcome (dependent variables) are recorded repeatedly for individual participants across time and varying levels of an intervention (independent variables). These varying levels of intervention are referred to as "phases" with one phase serving as a baseline or comparison, so each participant serves as his/her own control. (Lobo, Moeyaert, Cunha and Babik, 2017, p.2).

The present study, within the action research paradigm, incorporates some features of single case methodology; specifically, of the ABA withdrawal design (or ABAB (reversal) design)

[44] Note: 'Case study research' is not synonymous with 'single case research'. The former is concerned with building up a 'rich' description of an individual person, group, or institution in social context. The design is not experimental, and does not, for example, manipulate independent variables (Lobo, Moeyaert, Cunha and Babik (2017).

3.3: The ABA withdrawal design (or ABAB (reversal) design)

The purpose of SC methodology is to assess the value of an intervention (most commonly in a clinical or educational context) in improving a clinical condition (including rehabilitation) or in assisting learning (Krasny-Pacini and Evans, 2018; Gast and Ledford, 2014). The participant's initial condition, or existing level of performance, (the baseline) is measured (A_1). The intervention takes place (B_1). Using the same measure, the outcome of the intervention is assessed (A_2). A period of time sufficient to allow the measured dependent variable to return to baseline is allowed. The whole process is then repeated, usually a minimum of three times. If a post-intervention improvement in the dependent variable is observed on each occasion, it can be concluded that the intervention was successful. 'Withdrawal' and 'reversal' are both terms used to label the period taken for the return to baseline.

An important difference between clinical and educational applications should be mentioned at once. In clinical applications (where the intervention may be, for example, the administration of a drug) it is obviously essential that any effect is allowed to reverse completely before replication of the process (A_2). Any cumulative effect would contaminate the results (as well as potentially endangering the participant). In educational research, by contrast, a cumulative, or 'training' effect of the intervention would be a positive sign, indicating an improvement in learning following repeated interventions. Such a successful outcome is accommodated in action research, and is one illustration of its strength in an educational context, such as that of the current study.

Gast and Ledford (2014 p.226) set out guidelines for using the ABAB design – the SC design some of whose features have been taken as guidance in the present research:

1. Behaviourally define target behaviour(s).
2. Identify, behaviourally define, and concurrently monitor non-target behaviours of the same response class as well as behaviours that may change as a function of a change in the target behaviour.

3. Collect continuous baseline data (A_1) over a minimum of three consecutive days.
4. Introduce the intervention (B_1) only after a stable contratherapeutic or zero-celeration trend has been established in the initial baseline condition (A_1).
5. Collect continuous data during intervention (B_1) over a minimum of three days.
6. Withdraw (or reverse) the intervention and return to baseline condition (A_2) only after acceptable stability in both trend and level has been established in the first intervention condition (B_1).
7. Reintroduce intervention (B_2) procedures after a stable counter-therapeutic or zero-celeration trend has been established in the second baseline (A_2).
8. Attempt to replicate the experimental effect with similar participants.

Cerebral palsy is a condition that varies highly between individuals. In particular, individual behaviours due to physical disability, weakness, tiredness or pain need to be distinguished from behaviours that are selected as targets (Gast and Ledford guideline 1. above) to indicate that learning (or failure to learn) has taken place. Substantial initial observational work was therefore required in order to categorise Bob's *typical* behaviours so that *target* behaviours following intervention could be correctly interpreted. Similar work was required to assist interpretation of his behaviours as being on-task or off-task (the measure of attention, the dependent variable). Together, these two pieces of work partially fulfilled guideline 2. (above). Next, Bob's general ability to identify patterns, prior to the intervention employing specific pattern-tasks, was assessed. This provided baseline A_1 (guideline 3).

The three-day ideal (Guidelines 3 and 5) was not observed due to the demands of the school timetable, but the timing achieved was the best possible in the circumstances. The time-table and pattern of data collection is fully explained in chapters 4 and 5.

The inappropriateness of guideline 7 in a learning context was dealt with above. It was not possible in the time available to replicate the research with similar participants (guideline 8.)

These are the elements of the ABAB withdrawal design incorporated in the present action research. The ways in which data collection plans were adapted, in the action research tradition, as the requirements of the context and of Bob's individual needs unfolded, are detailed in the sections which follow in this chapter.

How additional information might have been obtained if a complete ABAB withdrawal design had been used, and how the design actually used could have been improved, are dealt with in the Discussion chapter, page 199.

In what follows, the organization of the current research is described in detail. The data collected from the single participant fall into three sections: a pre-intervention assessment; three initial post-intervention assessments and two post-intervention assessments. The two methods of data collection; observation and assessment are described.

3.4 Single-case methodology

While experimental assessments using control groups have been considered the 'gold standard' in testing the effectiveness of interventions, medical and some educational research has always needed to address problems of assessing interventions involving single-cases. The research of B.F. Skinner is an example of single-case methodology with studies of operant conditioning in individual animals. Since the 1950s, there has been a steady development of single-case methodology in clinical, educational and Special Educational contexts (Bijou,1957; Ferster,1961; Lindsley, 1960, cited in Kazdin, 2011). The present study draws on this tradition. Non-replicability creates difficulties for the assessment of interventions in single-cases. In the present study, temporal replication replaces case replication.

Kazdin (2011:59) in his influential book *Single-case Research Designs: Methods for Clinical and Applied Settings* lists six requirements for single-case studies. All are embodied in the present design.

1. *Evaluation instruments can be used repeatedly*. Calculation of time on-task following each intervention is used in each post-intervention assessment.
2. *Consistency of measurement*. On-task behaviours are clearly defined and easily observed by an experienced practitioner. A degree of inter-observer reliability is incorporated.
3. *Ability to register change.* This is ensured by 1. and 2. above.
4. *Dimensional scale.* Percentage time on-task was used to score every task.
5. *Relevance of the measure.* Time on-task was considered a direct measure of attention. Increase in sustaining attention was the objective of the intervention.
6. *Importance of the measure.* Attention is central among the cognitive functions involved in any learning, both theoretically and in classroom practice.

3.5 Rationale for a single-case study

As CP encompasses several neurological conditions that affect movement and coordination in different ways, a group design looking at averages of groups was not considered the most effective method in determining pedagogical approaches for an individual with CP. Educational research concerned with the assessment and development of an individual using a single-case design was therefore chosen. This design provided the flexibility to tailor an intervention to the specific characteristics of the individual which incorporated systematic observation, manipulation of variables, repeated measurement, and data analysis.

The decision to study a single child was made because this methodology enabled in depth data collection to explore attention in detail. This was because it was obvious that much closer examination of the abilities of individuals with CP was necessary than was commonly conducted. Secondly, attention was to be the focus, because this was easily observed. A very detailed observation schedule was necessary to form a clear picture of attentional ability in an individual with CP, and this imposed limits on the amount of data that could be collected for this study, hence the single-case. Thirdly and most importantly, an

intervention to see whether attention could be improved was proposed. If successful, this could be adopted and used by practitioners. Therefore, to address these aims a single-case study was designed. Instead of trying to identify the cause of possible cognitive difficulties, the aim was to determine if the attentional capacity of a child with CP could be improved. Kerns and Mateer, (1996) refer to 'sustained attention' as the ability to maintain a constant behavioural response over time when involved in a continuous and repetitive activity. This definition of 'sustained attention' is adopted for the present study.

A single-case design provided scope to explore any additional issues which were characteristic to Bob, 'the case'. For example, difficulties that could present as attentional problems due to associated medical factors including inattention due to fatigue or muscular pain.

3.6 Method and overall design

In this section a general overview of the method is provided. Detailed method sections for each phase of the intervention are provided in subsequent chapters which includes the materials and procedure for each activity, or set of tasks, and the results.

The research questions were:

- Can the attentional capacity of a child with CP be improved?
- What approach is needed to develop early mathematical understanding for a child with CP?

The 'A-B-A Withdrawal Design' (Campbell and Stanley, 1966) consisted of three phases:

1. pre-intervention (baseline) assessments
- typography of movement study
- pattern awareness assessment
- observations to establish on-task and off-task behaviours
2. intervention with assessments at three points (T1 T2 T3)
3. post-intervention assessments (P1 P2).

This design used repeated measurement of the dependent variable (sustained attention) throughout the duration of the intervention.

Triangulation[45] (Denzin, 1978; Patton, 1999), involving multiple data sources, was used to help facilitate deeper understanding of the case by checking the consistency of findings generated by different data collection methods. Instruments included primary data (researcher observations) and secondary data (information gathered from multi-professional sources: medical and educational reports). These sources of data were considered relevant to answering the research questions as they provided scope to look at the problem from different angles. As the views of different educational professionals were formed following informal classroom observations, triangulation provided an opportunity to explore their perspectives by looking at different data sources to consider the concerns raised (Denzin and Lincoln, 1994; Pettigrew, 1990; Stake, 1995; Yin, 1994).

Observation

There is a long history of using intensive behavioural observations of children, for example, Piaget's (1952) *The Origins of Intelligence* was based on such observation, of his own children. Other observational studies were outlined in the IFS, which used behavioural observation as a method of data collection. The present study builds upon the skills developed during the IFS and the rationale is similarly grounded in the notion that learning is not possible without engagement (Hargreaves, 2006). The design, with the inclusion of observations of a free activity enabled the case, (Bob), to become familiar with a range of materials through exploratory play. This enabled him to develop his familiarity of the environment, materials and researcher prior to the intervention. The use of video to record the sessions enabled detailed and repeated observation of behaviours including any nuances that would prove important. The time sampling technique used a five-minute observation session and entry at every five seconds (Arrington, 1932). This observational method and technique minimised bias by gathering quantitative data which measured frequency of occurrence of the on-task behaviours as opposed to making potentially subjective inferences/interpretations.

[45] Triangulation involves using multiple data sources in an investigation to produce understanding.

Observation of free activity with a range of classroom resources was first conducted. This was needed to ascertain Bob's ability to carry out practical tasks and produced a typography of Bob's movements when engaged in free (non-task related) activity. Two types of activity sessions were observed prior to the intervention.

1) undirected play sessions

This session was undirected in the sense that I did not instruct Bob in what he should do. The purpose of these sessions was to find out if Bob could handle and control equipment planned for use during the intervention. Play also provided time for Bob to practise the motor planning needed to explore and manipulate the equipment in different ways without having to focus on a directed outcome. The resulting movements would become the typography of movement study. This was essential in understanding Bob's range of movements in light of his medical condition and to establish his skills before planning practical activities. Its purpose therefore, was to determine whether any limitations of movement, due to motor impairment, were likely to cause problems accessing the intervention activities which could detract from attention to task rather than focus on motor planning. It was therefore designed to avoid a confounding factor[46] in interpreting the intervention data.

2) pattern awareness activities

The purpose of these was to establish the level of Bob's pattern awareness *prior* to the intervention sessions, during which Bob would be given tasks in which he was to be asked to identify or construct patterns.

This design provided scope to demonstrate that changes in behaviour (sustained attention) targeted by the intervention, were evidenced. This would happen if change was not sustained in the intervention but Bob's behaviour reverted to that seen during the pre-intervention assessments. It was presumed that confounding factors were unlikely to coincidentally occur at both the onset and interruption to the intervention. In this single case, possible factors that

[46] A variable that influences both the dependent and independent variable, which the researcher failed to control, or eliminate.

could account for an improvement in attention, other than the intervention did not seem plausible and were not measured (Skelly, 2012).

Prior to the pre-intervention assessments a series of informal observations were carried out. The purpose of these observations was to gain a rounded picture of Bob in his everyday learning environment. This was to determine if the environment was a possible factor in attentional difficulties when drawing conclusions after the intervention. It was therefore necessary to observe Bob in different environments to formulate an impression.

These informal classroom observations were carried out firstly, during a whole class literacy session, secondly, during the whole school assembly, thirdly, on the playground during morning break and finally, during a numeracy session in the classroom. The purpose was to gain an impression of attentional levels in different contexts and settings. These observations were not subject to the same level of analysis as the pre-intervention assessments, but provided an overall impression of engagement. These observations suggested to me, that Bob's attention was better when he appeared interested in the content, for example, when listening to the fairy-tale story during the literacy session, evidence of participation was noted. Whereas, during independent work on an individual task, Bob gazed around the room and engagement with the task was not evidenced

3.7 Organisation of the pre-intervention assessments

First, the pre-intervention baseline assessments were conducted over a four-week period. This involved 1) assessment of free activity, that is, undirected play and 2) a preliminary assessment of pattern awareness. In week five baseline assessment of understanding in pattern awareness was observed.

Pattern awareness

This series of observations was designed for the purpose of establishing what Bob understood about the term 'pattern', prior to the commencement of the intervention and subsequent planning of the initial tasks. Thus, the purpose was to inform the starting point for the intervention by identifying Bob's apparent awareness of patterns of different types based on his current understanding and assessed on what he can do on his own (see Vygotsky, zone of proximal

development, 1978). Activities with optimum potential to engage Bob's attention were important if a positive change in attention was to be used as a measure of increased understanding of pattern across the intervention.

The aim of presenting pattern in a variety of different ways, and using different resources, was to widen the inquiry to capture knowledge of pattern as a specific mathematical concept, but also within a broader sense, including visual patterns in the environment. Table 3.1 provides an overview of the tasks undertaken to ascertain Bob's level of understanding of pattern during the pre-intervention assessments. Repetition was planned across the observation period to check for consistent responses, for example, correct and intended identification of matching unifix strips, rather than guesses. The word pattern was avoided for some activities and alternative terms used instead including, 'match' and 'same as'. This was to ascertain understanding of the concept of pattern if Bob did not understand or remember the term.

Variables:

- Dependent variable - time on-task was not measured
- Independent variables - types of patterns and resources were changed
- Situational variables - changes affecting Bob's responses could not be controlled. These included interruptions and noise from the neighbouring classrooms.

Typography of movement study

Five weekly undirected play sessions lasting 25 minutes each were video recorded. Bob was provided with a range of practical resources to play with. The observations showed Bob's ability to remain engaged with an activity given his physical impairments. An observation schedule and coding system was devised for subsequent analysis of Bob's movement during the free activity. The first five minutes of each recorded play session was replayed using the video footage, and movements were coded on the observation schedule at consecutive intervals of five seconds. The following categories based upon typical motor development (Sheridan, 1973) were identified and coded for.

Rationale for the categories used:

- Head movements: uncontrolled head movements prevent Bob from looking at what he's doing. Control of head movements enables Bob to co-ordinate his hands and eyes.
- Postural control: uncontrolled upper body position inhibits hand eye co-ordination. Sustained upper body position facilitates hand eye co-ordination.
- Control of movement of arms for task activity where needed: uncontrolled arm movements impede success with an activity. Controlled arm movements enable goal-directed movements to reach and manipulate objects using the hands.
- Control of hands: Influences Bob's ability to maintain effective finger positioning for precise movements needed in some fine motor tasks.
- Use of hands: both (B) right (R) left (L). Enables Bob to make choices about the actions needed to access and manipulate objects during task activity.
- Reaches for objects. Enables Bob to select objects located further away.
- Grasps objects. Enables independence to select and hold objects during task activity.
- Manipulates objects. Enables Bob to interact with objects in different ways.
- Stabilizes object with one hand and manipulates with the other hand. Enables Bob to maintain an object within his palm whilst carrying out manipulation of another part of the object.

The following motor skills enable Bob to have greater control and independence when using and exploring a range of objects:

- Twists, turns, stacks, releases objects
- Pushes objects together, pulls objects apart
- Use-of-fingers: both (B), right R, left (L)
- Can grasp and hold objects with all fingers acting together
- Picks up small objects using finger and thumb
- Uses thumb in grasping objects

- Hand-eye coordination. Enables Bob to coordinate control of his eye movements with his hand movements when reaching and grasping objects during task activity
- Visual alertness and attention to relevant features of the task. Enables Bob to attend to objects, events and problems during task activity. Including the following:
    - Attention to hand carrying out task when necessary
    - Visually directed grasping
    - Reaches for object when both hand and object are in view
    - Grasps when just object is in view.

Baseline data

This baseline assessment data provided the basis to demonstrate that any changes in performance, following the intervention, were correctly interpreted. Additionally, as a minimum of three reference points are considered necessary to establish dependent measure stability (Kazdin, 2011), they were incorporated into this design. In the present study the reference points, (the assessments), provided a measure of the dependent variable (on-task behaviours) across the intervention. A transcript of a pattern awareness session can be seen in appendix two, page 247.

Thus, the Information to be obtained from the pre-intervention assessments included:

- establishing Bob's typical motor actions
- identification of Bob's existing level of understanding of 'pattern'
- description of on-task and off-task behaviours from analysis of the video footage
- measure of time on-task
- establishing if fatigue impacts upon performance by noting changes in actions over time during undirected play with the resources
- identifying pattern tasks suitable to Bob's abilities.

Nuisance variables (Kendall, 1968), which could not be controlled included environmental factors: adults entering the work space, noise from nearby

classrooms, the teaching assistant intervening and, changes on the day to availability of the meeting room.

3.8 The intervention

A series of activities[47] followed the pre-intervention assessments designed as an intervention to improve attention. Thus a pre-intervention observation of attention would be made, followed by an intervention designed to improve attention. Finally, the addition of two post-intervention assessments provided an opportunity to measure on-task behaviours to ascertain if 1) learning had been retained over time and 2) any improvement in attention had been maintained.

The idea of pattern was the central concept chosen for the intervention because it is central to mathematical understanding, as outlined in section 2.11, page 42. This design enabled me to observe Bob's behaviour before the intervention, during the intervention and after the intervention. Therefore any changes that followed from the intervention could be discerned. The assessments provided an important method of evaluating the effectiveness of each intervention phase and informing any changes if needed. The assessments were followed by an intervention withdrawal phase which involved withdrawal of the intervention which coincided with the school holiday period. Following the withdrawal phase, the ABA cycle was repeated twice to increase validity and reliability. The programme therefore ran for three complete cycles.

3.9 Intervention: session defined

A total of twelve intervention sessions were administered over two consecutive terms. These were scheduled in three blocks of four weekly sessions, then two lots of three weekly sessions. A 'session' consisted of a series of between five to eight activities using different practical resources including: coloured wooden shapes, Numicon, cuisenaire rods, unifix cubes and playdough. The focus of each activity related to the concept of pattern. The structure of each session consisted of an initial conversation with Bob so that he could tell me any news and ask any questions, followed by a pre-planned activity. After completing all

[47] Activities refer to the taught tasks within the intervention sessions. Different terms have been used to differentiate between sessions and investigations.

activities, which typically took thirty minutes, Bob had an opportunity to play with the resources which he found motivating and enjoyable.

3.10 Intervention: overview of sessions

On-task behaviours were recorded throughout the intervention phase so that any changes in attention could be accurately measured. The intervention sessions involved a series of activities using practical resources, to develop an understanding of pattern. For the purposes of the tasks pattern was defined as 'a systematic arrangement of numbers, shapes or other elements according to a rule' (DCSF in full, 2009, p.23).

The patterns used in the present study followed these principles, for example:

- red yellow red yellow (ABAB)
- tall short tall short (ABAB)
- sausage ball sausage ball (ABAB).

Numbers used as a pattern were subsequently taken out of the intervention to focus on patterns made from arrangements of shapes. This was considered necessary as numerical values appeared to be causing a possible confound between numbers as a pattern, and numbers in arithmetic. A focus on simple, visual arrangements which avoided additional cognitive demands contributed to the success of the intervention, in extending Bob's attention. My reflections as practitioner and researcher regarding the remodelling of the tasks are outlined in Chapter 9, section 9.4, page 200.

The intervention sessions began in the spring term for various practical reasons. Firstly, the pre-intervention assessments ended before the busy run up to the Christmas activities and play rehearsals. Secondly, by starting the intervention in the new term, the withdrawal phases could be planned around the school holidays to minimise changes to Bob's routine. This was also because withdrawing a potentially effective intervention/treatment is a general criticism of this type of design (Byiers, Reichle and Symons, 2012).

The intervention activities were carried out in a small room away from the classroom, whenever possible. This space was not always available and less suitable alternatives, including the staff-room and school hall were used out of

necessity. The staff-room was used once during the first cycle of the intervention, session four, and the hall was used for the second cycle, session two. The learning objectives which I planned for Bob covered the following:

- understand the term ‘pattern’
- learn to copy ‘repeating’ patterns
- begin to recognise that regular patterns follow rules
- learn to follow rules to continue ‘repeating’ patterns
- devise simple repeating patterns.

A teaching assistant was present during all of the sessions but she was requested to observe and not intervene. The sessions were recorded using a small camera placed on the table in front of Bob. Bob was aware that he was being recorded and enjoyed switching the camera on at the start of each session.

3.11 Intervention: assessment defined

An assessment, within the context of this study, is defined as an appraisal of Bob’s undirected performance when undertaking a series of pattern tasks. The first assessment formed the baseline prior to the start of the intervention sessions. Pattern tasks undertaken during subsequent sessions were repeated at four time points across the intervention. This provided a series of measurements of on-task and off-task behaviours so that changes in Bob’s attentional capacity could be assessed. Each assessment comprised a series of pattern tasks which Bob had experienced during the intervention sessions.

3.12 Intervention: overview

The resources that were used during the intervention were materials and apparatus commonly encountered in a mainstream classroom for early mathematical assessments. The theme of pattern was central to the intervention because of the importance of this concept in early mathematical learning. Because of this it was considered useful although attention was the focus.

The activities for each session were planned before the intervention and written on a sheet of A4 paper to provide a researcher prompt during the session. This

included the order of activities, resources, the type of pattern to be constructed and key language and terms to be used. An example can be seen in appendix three, page 256.

A camera was used to video record the entirety of the intervention. These recordings were replayed at a later time and researcher devised recording sheets used to code the information selected. This included:

- observation of movement recording sheets to establish typography of movements
- observation schedule to record and code on-task and off-task behaviours
- observation schedule to record prompts provided by the researcher
- observation recording sheets of motor actions.

As the intervention was planned around activities which were not being taught or practised at other times during Bob's daily school and classroom routines and lessons, sustained improvement from baseline levels would suggest the intervention was successful in effecting a stable change.

Table 3.1 shows the pattern, organisation and timeframe of the intervention, including the pre-intervention assessments, intervention sessions, assessments T1, T2 and T3, withdrawal periods and post-intervention assessments, P1 and P2.

3.13 Sample

The sample comprised one male child with a medical diagnosis of CP aged seven years. Bob was selected for the study because of concerns raised by the school about his memory and attention. Table 3.2 provides an overview of Bob, including details about his medical diagnosis and history and summary of difficulties summarized from the analysis of multi-professional reports.

3.14 Setting

The study took place in a mainstream infants' school in the Home Counties. The majority of sessions were undertaken in a quiet meeting room away from classrooms. However, as outlined earlier, when this room was unavailable alternative spaces were used including the assembly hall. This was also used as the dining hall and was a general thoroughfare for access through the

school. Bob used a specialist class chair for sessions with the exception of one, when the teaching assistant brought him in his wheelchair as they had been delayed.

Table 3.1 Details and time-line of the intervention: Pattern and organisation of sessions

Timeframe	Intervention	Activity
Autumn term	Pre-intervention baseline	Free activity play sessions Pattern awareness activities Observations to establish on-task and off-task actions
30 November	Assessment T1	Pattern awareness: Tasks 1-8
18 and 25 Jan, 1 and 8 Feb	Intervention	Activities
15 and 22 Feb	Withdrawal period	No intervention sessions
29 Feb	Assessment T2	Pattern assessment: Tasks 1-7
7, 14 and 21 March	Intervention sessions	Activities
29 March, 4 and 11 April	Withdrawal period	No intervention sessions
18 April	Assessment T3	Pattern assessment: Tasks 1-5
25, 3 and 9 May	Intervention sessions	Activities
16, 23, 30 May	Withdrawal period	No intervention sessions
6 June	Post-intervention assessment P1	Pattern assessment: Tasks 1-5
13 June-4 July	Withdrawal period	No intervention sessions
11 July	Delayed post-intervention assessment P2	Pattern assessment: Tasks 1-8

Table 3.2 Child participant in the study

Child Participant	Age	Diagnosis	Additional Medical Information	Difficulties accessing education[48]
Bob	7	Diplegia cerebral palsy and Periventricular Leucomalacia[1]	Selective dorsal rhizotomy[2] Possible epilepsy[3]	Fatigue[49] Easily distracted Asks questions out of context Inflexibility of thought Length of time needed to process information Language skills WM issues Retention of information

Notes:
Periventricular Leucomalacia[1] a form of white matter brain injury.
Selective dorsal rhizotomy[2] an operation used to improve spasticity (muscle stiffness) in CP.
Epilepsy[3] a group of neurological disorders characterised by seizures (Bob has experienced one known seizure).

[48] Based upon the impressions of teachers.
[49] Feeling exhausted, tired, weak, or lacking in energy.

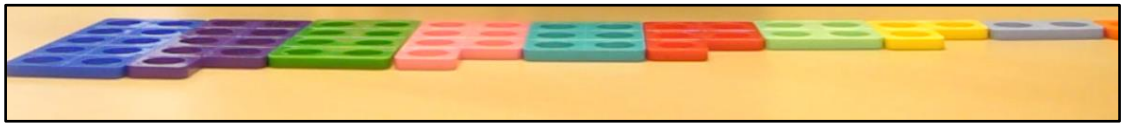
3.15 Instruments and materials

The following section outlines the instruments and materials that were used to collect data about Bob, the child participant. Recording sheets were specifically devised by the researcher and were not modelled on other recording sheets. In order to capture the level of detail needed a time framework of consecutive five second intervals were used. Examples of the completed recording sheets used for the pre-intervention assessments can be seen in appendix four, page 257.

An appraisal of Bob's numeracy skills was undertaken using the Numicon assessment tool. 'Numicon' (Atkinson, Campling, Tacon and Wing, 2014), is a practical teaching programme of explicit and progressive activities aimed at developing understanding of number and number relationships using visual Numicon images (Figure 3.1).

Figure 3.1 Images of Numicon used in the appraisal session

[1]



[2]

Notes:

[1] Numicon shapes 1-10. 1-shapes is not visible on photograph
[2] Numicon-pegs and Peg-board

How attention was measured

Systematic direct observation (SDO) was used in the current study. SDO has been used effectively by many psychologists for classifying and measuring behaviours (Cone, 1978; Wilson and Reschly,1996; Shapiro and Heick, 2004; Volpe, DiPerna, Hintze and Shapiro, 2005; Riley-Tillman, Chafouleas, Sassu,

Chanese and Glazer, 2008) and is widely considered to facilitate reliability and accuracy. Other measures of attention previously mentioned, see section 2.8, page 34, could not be considered by the present researcher since they may be administered only by qualified psychologists. These included the Wechsler Memory Scales, Mental Control tests, and Subtracting Sevens (Strub and Black, 2000) and the continuous performance test (Connors, 2014).

The piece of literature found to be most useful in constructing the observation measure used in the current study, was Behavioural Observation of Students in Schools (BOSS) (Shapiro, 2004).

Following Shapiro (2004), the measure of attention selected was time on-task. Time-on-task has been used in the fields of both education and educational psychology (Brünken, Plass, and Leutner, 2003). Off-task behaviours were also measured as they are generally associated with disrupted learning (Maykel, 2018). Off-task behaviours were then classified to help establish possible causes of Bob's disengagement from learning tasks. Once coded they were measured using a five second consecutive timeframe.

BOSS focuses on six behavioural categories: active engaged time, passive engaged time, off-task motor, off-task passive and teacher-directed instruction. In the present study, attention (engagement) was operationalised in terms of the overarching categories of on-task and off-task behaviour. Sub-categories of on-task and off-task behaviour were then devised which were appropriate to behaviours that were characteristic specifically of Bob. (See Tables 4.9 and 4.10, coding of on-task and off-task behaviours, pages 113 and 114). Of Shapiro's six behavioural categories, the present study made use of 'active engaged time', 'passive engaged time' and 'teacher-directed instruction' in constructing its sub-categories.

In other respects, BOSS was not an ideal measure in the present study. This was because it was devised for children within the classroom environment**,** whereas my interest was observation of an individual child out of the classroom context. For example, 'talking to a peer about something other than the current assignment' was not possible within a one-to-one teaching context and 'leaving

seat to throw a piece of paper in the trash' was not possible for a non-ambulant child.

Some behaviours *not* found in Shapiro, or in Maykel, Bray and Rogers, (2018) (see below) but important to record for Bob were: 'bouncing up and down in chair'; flapping arms about'; 'moving head from side to side repetitively'; 'resting head on table and not looking at the activity when visual attention required'; and 'sucking clothing/lunch wrist band and not responding to questions'. Some of these are suggestive of pain or fatigue. The importance of this is discussed later.

Two particularly useful features of BOSS were adapted for the present study. The first was BOSS's recommended method of recording behaviour every fifteen seconds over a fifteen-minute period. This interval was shortened when measuring Bob's on-task or off-task behaviour. The second useful feature was the high level of inter-observer agreement (ranging between 90 – 100% (Du-Paul, Volpe, Jitendra-Lutz, Lorah and Grubner, 2004) required by BOSS. Two experienced university researchers served as co-raters in the present study.

Certain sub-categories of active attention used by BOSS were excluded. These were: writing, reading aloud, raising a hand, talking to the teacher or peer about the activity and using a dictionary to find a word. They were excluded because during classroom-based observations of Bob, described in section 3.7, page 62, there was insufficient evidence of independent engagement in such tasks.

Maykel, Bray and Rogers, (2018) was also useful. Among on-task behaviours in the mainstream classroom Maykel et al., included: looking at the teacher when the teacher is speaking; looking at or writing on resources; speaking with a peer during collaborative working; responding to a question related to the task or asking a question about the activity. Conversely, instances of off-task behaviours included: speaking out of turn to the teacher, a classmate, or self; looking around the classroom; turning away from the teacher or class activity and fidgeting in or out of the chair and head resting on the desk. (Some of these were clearly not applicable in Bob's one-to-one context).

A further reason for not including items found in previously published work concerned certain behaviours, typical of a child with CP, that I had observed in Bob. Specifically, apparently off-task behaviours did not necessarily signal being off-task. For example, Bob's CP can cause episodes of fidgeting which according to Shapiro (2011) would be coded as off-task behaviour. However, fidgeting could be due to muscular pain. Movement (including fidgeting) can be an important pain management strategy and support task continuation. Similarly, motor movements affected by spasm and/or fatigue may result in Bob resting his head on the table, or to his upper body posture being slumped.

Such resting behaviour, and fidgeting itself, provides important breaks for Bob. Secondly, as a full-time wheelchair user, Bob is unable to make choices about leaving his seat. However, if the chair has not been positioned by an adult to provide optimal visual access, looking away from the teacher may be due to his placement rather than to inattention. Thirdly, I have observed instances where children with CP may be unable to integrate their senses, (Ayres, 1963, 1968) and will therefore not look at and listen to a speaker simultaneously.

3.16 The researcher

My conduct as a researcher was consistent throughout the intervention. I introduced myself informally and maintained a relaxed demeanour during all sessions. This was to create a comfortable atmosphere without any pressure so that Bob could engage with the activities without worrying about his performance. The nature and purpose of the sessions was explained to Bob's teaching assistant prior to the start of the intervention. The teaching assistant was present for each session and was reminded not to intervene at the start of each session. This was so that Bob's independent responses could be observed, including his approach to problems.

Although Bob was encouraged to access the resources independently discreet help was sometimes provided. For example, if the fine motor demands of a task and precise placement of resources were causing problems for Bob, support was offered. After providing an instruction I waited to enable Bob time to process the language and respond when he was ready to.

3.17 Data analysis

The materials and procedure for each phase of the intervention are described in detail in subsequent chapters. This section provides an overview of how the data was analysed across the study.

Secondary data for the multi-professional reports, including reports written by specialist teachers, which were outlined in my review of unpublished literature, were coded based on thematic analysis (Miles and Huberman, 1994) as a method of finding key words, patterns, concepts, themes and meanings across reports. Analysis consisted of six stages: familiarisation with the data, coding the data, searching for themes, reviewing the themes, defining and naming the themes and writing-up to contextualise the data (Braun and Clarke, 2006). This process was undertaken manually through systematic readings of the reports and using a set of coloured highlighter pens.

Themes which linked to the research questions and aims of the study were identified from the literature review. I then highlighted all the words which related to possible barriers to learning. Following this I wrote down the word and its context and subsequently sorted these into groups with similar meanings, in order to identify the themes.

Themes and possible barriers to learning for children with spastic diplegia CP included the following:

- motor skills (fine and gross)
- memory (included short-term memory, long term memory, working memory, auditory and visual memory)
- attention (poor concentration)
- social and emotional (included play and interaction, feeling different, being bullied or feeling socially isolated)
- mathematics (included pattern, sequence, shape, space and measuring)
- medical (included poor sleep, muscle pain, fatigue and epilepsy).

The observation schedule was devised so that motor actions could be recorded. These were verified by an experienced university researcher who acted as an independent inter-rater observer. A small sample of two observations were rated using the video recordings. Inter-rater reliability checks suggested minor

discrepancies of less than 10% of the sample which were easily resolved through discussion.

Analysis of the assessments and intervention sessions

1) The video recordings were analysed using coding categories.
2) Additional analysis of the assessments was undertaken.

How the Typography of Movement informed the choice of coding categories

Motor control may improve through motor memory associated with the repetition of similar actions, while cognition may not improve (Dordić, Tubić and Jakšić, 2016). Consequently, an improvement in task performance could be observed alongside a decrease in engagement. Therefore the typography of movement provided the basis to demonstrate that any changes in performance, following the intervention, were correctly interpreted.

The main coding categories were 'looking', 'handling', 'speaking', 'hand-used' and 'location'. These came about through a process grounded in the pre-assessment observations of Bob's free play activity. These observations informed decisions on the choice of 'actions' to be coded for.

Actions

'Actions' refer to Bob's behaviours during activities, specific actions and sub-divisions included:

- Looking (at the researcher/teaching assistant or object)
- Handling (reaching towards or pointing-at)
- Speaking (vocals).

The reason that actions were sub-divided was so that Bob's attention could be considered in relation to the context of the task. For example, when the teaching assistant made a movement, sound or comment that distracted Bob, his on-task attention was disrupted. It was therefore helpful to record where Bob's visual attention was directed at the point of distraction. The inclusion of 'reaching towards' and 'pointing at' provided evidence of on-task attention and motor movement. The inclusion of 'pointing at', as a discrete code, was helpful when undertaking assessment of understanding. This was because Bob was

able to gesture through hand movements, for example pointing, as a means of non-verbal communication if spoken articulation of his thinking was difficult. 'Reaching towards' provided evidence of attention when placement of resources was out of reach. Increased effort by Bob, therefore demonstrated continued engagement despite his motor difficulties.

Making sound effects (vocals) was included as a sub-category of speaking to ascertain whether off-task behaviours were linked to occurrences of vocalisations. Based on this notion, a decrease in vocalisation would be anticipated if attention levels increased throughout the intervention period. As observations of the undirected play, during the pre-intervention assessments demonstrated left hand dominance, I was interested in evaluating whether the outcomes of the practical activities (used in the intervention sessions) corresponded with these findings. This is why 'hand used' was included in the coding categories.

Rationale for the inclusion of additional codes

Additional codes included:

- Hand used (right-hand, left-hand, both-hands-together)
- Location (front, front-left, left, front-right, right)

Occupational therapists provide advice to schools on the development of fine motor activities for children with physical impairment. These are typically undertaken as isolated tasks rather than being incorporated throughout the day. As children with CP often carry out therapeutic programmes during the school day, as a separate activity and away from the classroom, it was reasoned that a plan to integrate fine-motor activities within daily tasks could provide increased opportunities for Bob's inclusion. For that reason 'hand used' was included as a coding category. This was to determine if the practical activities resulted in any changes in typical hand actions. For example, whether the manipulation of playdough, which could be part of a therapeutic programme, resulted in increased episodes of Bob using his right hand or both hands together to a greater extent. If there was evidence of this, it seemed plausible for the school to consider a more integrated approach to supporting the educational and therapeutic objectives within practical activities.

The rationale for other codes were similarity grounded in pragmatic considerations: the rationale for including 'location' when coding the baseline assessments arose because 'location' refers to the area of the table in relation to Bob's positioning. These were recorded as: front, front-left, left, front-right or right. The purpose of coding location was twofold; firstly to ascertain if left hand dominance remained typical, and secondly to establish if placement of objects was an important consideration in terms of practical and visual access. This was because there were occasions when Bob appeared to be moving objects presented in a long horizontal line, by sliding them towards the 'front' location. Initially, this action was interpreted as disengagement from the task rather than a constructive action to access the resources.

3.18 Events

'Events' arose because, when coding the video observations timeframes of consecutive ten second intervals were used. Events refer to the series of actions observed within a ten second timeframe (see Figure 3.2). Thus, each timeframe represented a ten second unit of time, each unit of time was broken into events and each event showed the order in which actions were observed. For each unit of time the number of events varied, depending upon how many actions were observed. Each new event was recorded vertically on the coding sheets in the exact order they were observed (see appendix four, page 260).

Before deciding on the unit of time, different lengths were tested. I wanted to capture the detail of Bob's movements to determine if they were affecting attention due to the level of effort needed to perform repetitive practical tasks. I started to code an observation using a twenty second unit of time. This was unsuccessful as there were too many actions to remember and code accurately. From a practical perspective, it wasn't efficient to stop/start and re-run the video several times. For that reason I trialled a five second unit of time. This was successful in terms of remembering and recording the coding accurately. However, this didn't capture the flow of Bob's movements, due to the pace and precision he needed to achieve success. Consequently, a ten second unit of time was decided upon. When different actions were observed it was still necessary to re-run the video recording, to increase accuracy. However,

sequences of actions such as visual location, motor-planning and handling, often occurred within the timeframe.

The purpose of coding the video recordings was to provide evidence of changes in Bob's learning behaviours over the intervention period. Recording the length of time for each action therefore became an issue. Recording actions as separate events within each ten second interval provided detailed data and it was therefore not deemed necessary to time the precise length of every action. For that reason, the length of time any gaze persisted was not taken into account when counting 'looking events', and a brief glance and longer gaze counted equally as one event. As processing speed can be affected by CP, as well as motor control, it would not be appropriate to record the length of time taken on each action. This is likely to fluctuate depending upon factors beyond Bob's control, including: weather linked to degree of muscle tightness, fatigue, pain, amount of sleep and medication. It was hoped that results of the intervention would demonstrate an increase in on-task behaviours rather than faster response times. It was decided that 'speaking' would not identify the type of utterance but 'vocals' would be recorded separately to see if occurrences decreased as attention levels increased.

In what follows:

- A movement or action is referred to as a 'behaviour' (plural: 'behaviours')
- A goal-directed *sequence* of behaviours is referred to as a 'sequence'.

Figure 3.2 Intervention T1 Task 1: Example of raw coding to illustrate a series of events. The number of observed events within each 10 second timeframe varies.

Timeframe on video recording[1]	LOR[2]		H[3]	S[4]	HU[5]	Loc[6]	Sequence of actions
0-10	-[7]	-	-	Speak	-	FR	(on-task)
	O	RES	-	-	-	R	Speaking
11-21	-	-	R-T	-	LH	FR	Looking
	-	-	P-A	Speak	LH	R	Handling
22-32	-	-	H	-	LH	FR	
	O	-	-	-	-	FL	Speaking
	O	-	P-A	-	LH	FL	Handling
	-	RES	-	Speak	-	R	Looking
	-	RES	-	-	-	FR	
33-43	-	RES	-	-	-	-	Speaking
	-	-	-	Speak	-	-	Looking
	O	RES	-	Speak	-	FR	Handling
	-	RES	-	Speak	-	F	
	-	-	H	Speak	-	-	Speaking
	O	-	H	-	LH	FL	Handling
44-54[8]	O	RES	-	-	-	R	Looking
	O	-	R-T	Speak	LH	FR	
	O	-	H	-	LH	R	Handling
	O	-	P-A	-	LH	F	Looking
	O	-	P-A	V	LH	L	
	O	-	P-A	-	LH	L	
	O	-	P-A	-	LH	FL	

Notes: -
[1] Seconds
[2] Looking at object, researcher or teaching assistant
[3] Handling. Pointing at or Reaching towards
[4] Speaking or making sound effects (Vocals)
[5] Hand Used Left, Right, Both
[6] Location Front Right, Right, Front Left, Left, Front
[7] Event space
[8] 8 events within this 10 second timeframe

Capturing sequences as a series of time related and ordered actions

This meant that when observing every event within each ten second unit of time, a judgement was made to decide what the predominant action was. For example, if Bob visually located an object, before reaching towards it, this was recorded in the 'sequence' column of the coding sheet, as 'handling'. This judgement was made for *every* event and recorded in the corresponding row. The sequence started and finished when Bob was either on-task or off-task continuously across consecutive events. At the end of each period of on-task or

off-task periods, actions which had been repeated in consecutive events were deleted. An example is provided next:

Looking
~~Looking~~
~~Looking~~
Speaking
Handling
~~Handling~~

The actions in this sequence were subsequently recorded as:

Looking
Speaking
Handling

The purpose of recording the sequences was to evaluate changes in patterns of Bob's behaviour over the intervention. This in turn led to the strategy for coding the video material. This involved a series of steps using the following procedure:

- Observe the video recording at sequential ten second intervals.
- Pause the video recording at the end of each ten second timeframe.
- Record the main action or actions on the coding sheet under the relevant heading.
- Record this action in the sequence column.
- If two actions occur simultaneously record them on the same row. For example, making eye contact with the researcher whilst speaking to her, or looking at an object whilst handling it.
- If two actions occur simultaneously use a professional judgement to decide what the focal action is and record in the sequence column, in the same event row.
- Record every new action(s) on a separate line to show the order of events observed.
- When one action occurs in isolation record separately as an event. For example, intentional looking before another action is observed.

- If an action is observed a fraction ahead of a subsequent second action, record as one event on the same line. For example, look and reach-towards.
- If an action continues into a new ten second interval, code it again to demonstrate flow.
- Record when Bob's behaviour changes from on-task to off-task and back to on-task.

Additional guidance:

- Use professional judgment when coding events.

Additional analysis of post-intervention assessments

Each assessment task underwent additional analysis to provide data on the percentage of time Bob was on-task or off-task. The video recording was played and a recoding schedule was completed for all of the assessments. On-task codes (Table 4.9, page 113) were used to record Bob's behaviour in consecutive five second intervals from the start to end of each assessment.

3.19 Ethical considerations

The guidelines set out by the British Educational Research Association, BERA, (2011) were followed. Consent to conduct this research study, during working hours, was gained from senior management of the local authority Children's Services of which I am an employee. The study was discussed with specialist teachers within the team and verbal consent gained for their involvement.

Signed written consent to work with children is always gained from parents/carers before any involvement by Children's Services and was specifically obtained for my involvement with Bob. The nature of involvement is outlined on the referral form which parents/carers sign before our involvement. Ethical clearance for research with Bob was gained from University College London and permission to undertake the research with Bob was sought from senior management at the school. Before requesting verbal consent from parents, I met the Special Educational Needs Co-ordinator (SENCO) at the school to discuss the research. The SENCO had developed a good relationship with the parents and was able to make an informed judgement as to whether they would wish Bob to be involved in the study. I then asked the SENCO if she

would have a preliminary discussion with the parents to outline the study and ascertain if they were interested. This was considered important so that parents did not feel under any pressure to agree. As a Local Authority employee and 'specialist', I was concerned that parents may have felt awkward refusing permission if I approached them myself.

When verbal agreement had been gained from the SENCO, I had a meeting with Bob's parents. Verbal consent was given by Bob's parents; and a robust programme of discussion, consultation and involvement was undertaken with them. Bob's mother, particularly, was working in the school throughout the research, and was on hand for discussion.

I felt that the research would be better explained in a face-to-face meeting and would provide the opportunity for Bob's parents to ask questions about the research and receive information about measures to ensure confidentiality and their right to withdraw Bob from the study at any time.

I explained the aims of the research, and the research procedure, as follows: Firstly, a series of undirected play sessions would be undertaken to inform my knowledge of Bob's physical access to resources and his understanding of pattern. Secondly, I would work on a one-to-one basis with Bob with the aim of supporting his development of early mathematical understanding and to improve his attention. The timeframes were outlined and a detailed plan subsequently sent to the SENCO (appendix five, page 261).

At this meeting parents wanted to know who would be involved and specifically who would have access to the video recordings. I described the role of my supervisors and reassured them that their guidance throughout the intervention would be provided. I explained that the video recordings would be shared with my university supervisors for the purpose of increasing rigour and to corroborate views about the intervention. I explained that a pseudonym would be used in the thesis to protect Bob's identify and to maintain confidentiality. I explained that they could decline permission, and could withdraw Bob at any time from the research without giving a reason. These assurances were not given in writing.

Throughout the intervention Bob's mother was undertaking some voluntary work at the school which provided an opportunity to discuss the intervention sessions with her. She was invited to observe a session but declined as she felt her presence would distract Bob from the activities. I offered to provide copies of the video recordings so that parents were able to see the work. The video recordings were copied onto DVDs and handed directly to Bob's mother at the school.

A regular email dialogue was maintained with the SENCO and class teacher throughout the study. Updates included any changes that would be implemented following supervision at university. I offered to meet Bob's parents at any time to discuss the study and ensure transparency at all stages. Parents were also offered the opportunity to be debriefed as to the main findings of the study on completion.

Guidelines for complying with service policies relating to equality of opportunity, inclusion, access and anti-bullying were followed. Paper-based research data generated from the observations were retained securely in a locked cupboard with restricted access. Results of the AWMA assessment were stored on a password protected laptop. Video recordings made during the intervention were stored on a password protected laptop, accessible to the researcher and no other individuals.

As detailed above, consent to video record the intervention was gained from the school, Bob's parents and additionally from Bob. Examples of photo images to be used in the thesis were shown to Bob's mother and her verbal consent to include them was gained. To maintain anonymity, Bob's upper-body was cropped out of all images so that his face remained concealed. The ethics of withdrawing a potentially beneficial intervention was addressed by planning withdrawal periods around school holidays.

3.20 Validity

To ensure methodological rigour, the following research actions were taken to increase the credibility of findings:

- Ongoing critical reflection as a researcher and practitioner to continuously question the efficacy of approaches taken, tools used and data collected.

- Undertaking detailed observations during the pre-intervention assessments to inform the coding of behaviors characteristic to Bob given his motor impairment.
- Gaining the views of multi-professionals, parents and the child participant to ensure different perspectives were gained.
- Systematic observation of the child participant in different contexts/settings using a combination of informal notes and structured observation schedules designed for the purpose.
- Thorough interrogation of the video recorded observation data and systematic coding of behaviours.
- Repeated viewings of several video recorded observations with two experienced university researchers to scrutinize behaviours and cross-check the coding system.
- Scoring of the typography of movement checked by a university researcher to increase reliability.
- Incorporating data triangulation so that different methods and perspectives increased the credibility of findings, using for example, reports written by educational psychologists and specialist teachers.
- Scrutinizing the data from different angles and looking at visual patterns so that findings were accurately reported.

3.21 Dissemination of findings

Following the present study information was disseminated to the school and parents in a written report and they were also offered an opportunity to meet me and discuss the findings. My team of specialist advisory teachers were involved through discussions at team meetings. In addition I presented information about WM to increase their awareness and I trained them to use the Automated Working Memory Assessment and Working Memory Rating Scale. I undertook a number of joint visits to support them and to discuss strategies to help schools. As a result of the research possible WM difficulties has been embedded in their practice and information has been disseminated through their work with schools. Similarly, dissemination of the study has been ongoing with the team through discussion about the research, throughout the course of the study, including details of the intervention and tentative findings. When Bob

moved to the Junior School, I met with teaching staff to provide an overview of Bob's difficulties, and provided a double-sided laminated A4 sheet outlining support strategies. On a separate visit I observed the new teaching assistant working with Bob during a one-to-one session. I provided advice on strategies to support and scaffold learning as opposed to completing the work on Bob's behalf (which I had observed). On a separate visit I worked with Bob whilst the new teaching assistant observed in order to model the pattern work and provide examples of how it could be extended.

The chapter has outlined the general method and design of the present study. It has described the purpose of gaining the pre-intervention assessments and provided an overview of the intervention. The rationale for the choice of observation as a method was provided and reasons why the analysis was deemed credible outlined.

Chapter 4: Pre-intervention assessments

4.1 Introduction

This chapter provides full information about Bob, the participant, including his case history and various appraisals of his abilities by practitioners and others. It also reports an important pre-intervention observation of his physical movements and of his awareness of pattern, and an appraisal of his elementary number skills. All of these informed planning of the intervention. A schedule of on-task and off-task behaviours, based on the same observations and used as an index of attention, is also presented.

4.2 Case history

At the time of the study, Bob was seven years old and in his last year at a mainstream infant school. Parents attributed his low attainment to lengthy absences from school for surgery and ongoing medical appointments.

Practitioner observation of Bob suggested that he had *possible* WM difficulties, although results on the Automated Working Memory Assessment (AWMA) did not support this view. Whatever the cause, Bob continues to struggle with classroom activities. He needs high levels of support to meet the cognitive demands of the fast-paced learning environment needed for the National Curriculum and Programmes of Learning. These are statutory for all local-authority maintained schools in England (Department for Education, 2013).

From my observations of Bob during classroom activities, it seemed that the degree of highly directed one-to-one support he was receiving was impeding his ability to develop independent goal-directed learning skills. At this time, Bob's attention to task was reliant upon continuous adult prompts due to distractibility. Once side-tracked, he seemed unable to re-engage with a task without adult directives. It thus seemed clear that to support Bob, he needed to extend his attentional skills in order to aid WM.

Bob is a full-time wheelchair user as he is unable to weight bear or walk without the use of specialist equipment. Bob is dependent upon adults for all transfers, including personal care and for access around the school site. The high level of moving and handling throughout the day inevitably takes time and

subsequently, parts of lessons and opportunities for social interactions are missed on a daily basis.

Multi-professional reports about Bob

Reports gathered to provide secondary data included: educational records of visits written by specialist teachers and educational psychologists (EPs), medical reports written by paediatricians following medical examination; written updates from physiotherapists after assessment of flexion/extension[50] and reports written by occupational therapists following clinical assessment of specialist seating and/or fine motor function. These reports are generally circulated to all professionals, with parental consent, as part of effective multi-disciplinary practice. They were useful in providing relevant clinical information which could possibly affect educational performance, for example, epilepsy, fatigue, muscular tension and pain.

Procedure

Medical reports, specialist teacher and EP reports and assessments were photocopied. I read each document and highlighted phrases, using coloured highlighter pens, which indicated barriers to learning. For example: organisational skills, memory, attention, carrying out instructions, motor skills, fatigue, independence, fine and gross motor skills. I then organised this information into headings and, summarised the relevant findings. Difficulties accessing education included: fatigue, distractibility, asking questions out of context, difficulties with language, WM issues and retention of information.

Observations of Bob

In the classroom and assembly I sat at the side of the classroom/hall and made notes in an exercise book about the lesson and Bob's responses. In the playground, I stood by the exit and observed Bob from a distance, in order to remain unnoticed and gain an impression of his access to play and interactions with friends. I made notes in an exercise book. The information obtained suggested that Bob was able to attend to aspects of the whole class literacy lesson but within the larger environment of the hall, he appeared distracted

[50] Movements that affect the angle between two parts of the body.

during the assembly, for example, gazing about and not looking at the head teacher. He interacted with two peers during playtime and appeared to be happy. This was evidenced through laughter and chatting.

4.3 Assessment of mathematical understanding using Numicon[51] materials

An informal assessment of Bob's mathematical abilities, using Numicon, was undertaken on a separate visit. Assessment materials from Numicon assessment tool were used to gather information. Specific assessment activities included the following:

Can Bob order shapes[52] and give them number names?
How to find out -

- Give Bob a set of jumbled one to ten shapes. Ask Bob to put then in order starting with the one-shape.
- Point to a six-shape and ask Bob to say its number name. Continue to ask Bob to name each shape (not in order).

Can Bob match shapes and copy the pattern of a shape with pegs in the baseboard?
How to find out -

- Show Bob a seven-shape and ask him to make the corresponding pattern with pegs on the baseboard
- Make a nine pattern with pegs on the baseboard and ask Bob to find the corresponding shape.

  Can Bob combine the shapes to show addition and explain using the words 'add, plus and equals'?

  How to find out -
- Give Bob a three and four-shape and ask him to add them together and say the addition.

From this assessment, I concluded that Bob was familiar with the Numicon resource and seemed confident using it. He demonstrated awareness of the shapes and number they represented and could select the correct shape that

[51] 'Numicon' (Atkinson, et al., 2014) is a practical teaching programme of explicit and progressive activities aimed at developing understanding of number and number relationships using visual Numicon images.
[52] Shapes refers to Numicon pieces to represent numbers one to ten.

represented a number. With support, Bob could make a shape on the pegboard but he was unable to do the addition task.

4.4 Typography of movement

The routine described next, was applied for all the pre-intervention assessments. Firstly, Bob was responsible for taking the camera out of the cover and passing the camera to me. This was because he enjoyed doing this and it became an integral part of our routine. In addition, it ensured that Bob was aware of being recorded, in line with the ethical standards followed during this study. Secondly, I positioned the camera on the table in front of Bob and his work space and turned it on for the duration of the session.

Materials

A selection of Numicon materials was provided including: shapes, Numicon board, pegs, and cuisenaire rods (see Figure 4.1). The materials were selected because they support early mathematical understanding using pictorial representations of number concepts. Additionally, concrete resources[53] to encourage mathematical learning are generally considered useful (Office for Standards in Education, 2012). Manipulation of these materials required a range of motor skills which enabled me to assess Bob's ability to access them independently of task performance. The intervention sessions were planned to incorporate Numicon resources which were used in the school and considered an effective practical approach.

Procedure

Week one

Bob was taken to a small room used for meetings so that he could focus on the play session in a quiet area of the school, with minimal noise and interruptions. Bob's teaching assistant was present and sat on his right side; she was requested to observe quietly during the free play activity. Bob was seated in his specialist class chair and positioned at the correct height for access to the table and resources. The activity started with 'chit-chat' so that Bob felt comfortable,

[53] For example, everyday objects and mathematical apparatus such as: counters, unifix cubes and wooden shapes.

and had an opportunity to get to know me, prior to the intervention sessions. I then explained that Bob would have an opportunity to play with some different resources, so that I could see if he found any of them tricky to use. I had informed Bob, during a previous visit, that I would be doing some work with him using Numicon. I asked Bob if he was happy for me to video the play, using my camera, so I could watch the session at a later time. I positioned the camera on the table so that Bob was fully aware of being recorded and could get used to this before the intervention sessions commenced. I placed a range of different Numicon resources on the table, within Bob's reach, and told him he could play with them. I sat to the left side of Bob and did not intervene. When Bob played with the resources, I only responded with comments in response to Bob's interaction with me, otherwise I observed quietly, remaining still to avoid distraction.

Weeks two, three, four and five

The procedure for week one was followed for all subsequent free activity play sessions. However, as the meeting room was unavailable, the sessions took place in an additional learning area outside two classrooms. The classroom doors were open for some of the time and noise was audible; this was not a factor I was able to control. Bob was seated in his height adjustable specialist class chair for all sessions except week four. Due to time factors Bob was kept in his wheelchair which was not height adjustable, but he was able to access the resources. The lighting was poor in this area and there were often staff or children walking through which created distractions. Bob's teaching assistant was always present. Due to environmental distractions which were notably affecting Bob's attention, the teaching assistant agreed to try and locate a quiet space for the subsequent intervention sessions.

Figure 4.1 shows Bob playing with resources during the free activity play sessions which were used to inform the typography of movement. The images illustrate a range of motor movements Bob used to access the resources.

Figure 4.1 Images of Bob playing with resources during the free activity play sessions

Timeframe	Typography of movement	Activity: undirected free play using practical resources
28/09/2015	Week 1[1]	
05/10/2015	Week 2[2]	
12/10/2015	Week 3[3]	
19/10/2015	Week 4[4]	
26/10/2015	Week 5[5]	

Notes:
[1] Bob uses his right hand to stabilise the pink tray whilst stacking with his left hand. Body posture is leaning to right-side.
[2] Bob transfers the peg from right-left hand to stack on top of the ten-shapes.
[3] Bob uses both hands at the same time to access the resources.
[4] Bob uses fingers on his left hand to hold the ten-shapes stable.
[5] Bob has pushed Numicon-pegs on to three fingers on his right hand, used to stabilise posture whilst leaning forwards to release Numicon shapes in his left hand.

Results

Head movements during play sessions

The first set of results focused on Bob's head movements. The following categories were observed:

1) Movements prevent Bob looking at work
2) Control of head movements allows Bob to co-ordinate hands and eyes.

There were no (0%) recorded instances of head movements preventing Bob from looking at his work. Observations showed that head movements were controlled at all times (100%) to co-ordinate hands and eyes. It is therefore clear that Bob can control his head movements at all times. This is important because it will enable him to use his vision effectively to: locate and track equipment, observe the movements of his arms and hands to reach, grasp and manipulate objects in the intervention.

Postural control during play sessions

Results showed that Bob maintained an upper body position to enable hand-eye coordination all (100%) of the time observed. As Bob lacks independent mobility, this means that when in his specialist seating he can maintain upper body control to access equipment within his reach. Good postural control will support planning of efficient goal-directed movements. The following results summarised in Table 4:1 relate to 'control of arms'.

Table 4.1 Control of arms during play sessions

Control of arms	*Weeks*				
	1 (%)[1]	2 (%)	3 (%)	4 (%)	5 (%)
Both-arms	78	64	49	45	39
Right-arm	0	0	0	0	0
Left-arm	22	36	51	45	61

Notes: %[1] Percentage of time movements were observed during the first 5 minutes of undirected play. Values round up to nearest whole value.

Control of arms during play sessions

Results illustrate that Bob can control the movement of both arms during play sessions. There was no evidence of right-arm use in isolation. Use of both-

arms together decreased over the five week observation period and use of left-arm used on its own increased.

The results presented so far, clearly show that Bob can control his head and arm movements. Figure 4:2 illustrates how Bob controls both arms to achieve his goal.

Figure 4.2 Photograph to illustrate control of arms during play sessions

Using left hand to move and release Numicon shapes from peg board to the Numicon box[1]

Notes:
[1] Right-arm and hand used to stabilise upper body as Bob reaches with his left-arm to release Numicon shapes using his left hand.

The next results relate to 'control of hands'. Hand reach, in motor-impaired children, can involve the whole trunk and arm in order to decrease the number of joints to be controlled. An example where Bob appears to be doing this is illustrated in Figure 4.3.

Control of hands during play sessions

Results illustrate that Bob can control the movement of both hands for tasks. Consistent with earlier results, it is clear that Bob will only use his right hand when both hands are needed to achieve his goal. The following three tables focus specifically on hand-use. The first results, presented in Table 4.2 relate to reach, grasp and manipulation of objects.

Figure 4.3 Photograph to illustrate control of hands during play sessions

Control of both hands for task

Notes:
[1] Use of both hands to grasp and position resources

Use of hands in play sessions: reach, grasp and manipulation of objects

The results demonstrate that Bob reaches for objects using his left hand, regardless of where an object is positioned on the table. Occasionally, Bob will reach for objects using both hands. Bob never reaches for objects using his right hand in isolation, even when objects are closer to it. Bob predominantly grasps objects using his left hand. He can grasp objects using both hands together but does not use his right hand in isolation. Bob will manipulate objects predominantly using his left hand, but sometimes will use both hands together.

Table 4.2 Use of hands in play sessions: reach, grasp and manipulation of objects

Use of Hands	*Weeks*				
	1 (%)[1]	**2 (%)**	**3 (%)**	**4 (%)**	**5 (%)**
Reaches for objects					
Both hands	0	15	0	14	3
Right hand	0	0	0	0	0
Left hand	100	85	100	86	97
Grasps objects					
Both hands	80	41	35	34	0
Right hand	2	0	2	0	0
Left hand	18	60	64	66	100
Manipulates objects					
Both hands	7	28	22	35	9
Right hand	0	0	0	0	0
Left hand	94	73	79	66	92

Notes: %[1] Percentage of time hand movements were observed during the first 5 minutes of undirected play. Values round up to nearest whole value.

Use of hands in play sessions: stabilising and rotation of objects

Results demonstrate that Bob can stabilise an object with one hand and manipulate it with the other hand when necessary to achieve his goal. Additionally, he can rotate and examine objects when required for the task.

The increased number of times these actions were observed during week four is noteworthy. Increased familiarity with this resource suggests he was able to manipulate them in more intricate ways. Previous observations involved stacking and moving the Numicon shapes from the Numicon box to the table and back.

Table 4:3 Use of hands in play sessions: stabilising and rotation of objects

Use of Hands	*Weeks*				
	1 (0)[1]	**2 (0)**	**3 (0)**	**4 (0)**	**5 (0)**
Stabilises object with one hand and manipulates with the other hand	0	15	6	31	4
Rotates and examines objects	10	8	6	29	20

Notes: %[1] Number of times observed during the first 5 minutes of undirected play

The final results relating to hand use are presented next and displayed in Table 4.4.

Use of hands in play sessions

Results provide evidence that Bob can use his hands to: twist, turn, stack and release objects, pull them apart or push them together.

Table 4.4 Use of hands in play sessions: twist, stack, release, pull/push

Use of Hands	Weeks				
	1 (0)[1]	**2 (0)**	**3 (0)**	**4 (0)**	**5 (0)**
Twists objects	2	1	0	12	1
Turns objects	3	2	3	3	12
Stacks objects	20	0	16	9	2
Releases objects	4	8	27	16	20
Pushes objects together	3	0	1	14	8
Pulls Objects apart	3	0	0	3	5

Notes: 0[1] Number of times observed during the first 5 minutes of undirected play.

Figure 4.4 provides an illustration of Bob using his fingers to access a resource during a play session.

Figure 4.4 Photograph to illustrate hand movements during play sessions

Using the right hand to enable left hand to rotate and push[1]

Notes:
[1] Right hand used to hold a Numicon peg in position whilst left hand places 7-shape on the end of it.

The following table, Table 4.5, shows Bob's use of fingers during the play sessions.

Table 4.5 Use of fingers in play sessions

Use of fingers	*Weeks*				
	1 (%)[1]	**2 (%)**	**3 (%)**	**4 (%)**	**5 (%)**
Can grasp and hold objects with all fingers acting together					
Both hands	74	60	28	32	0
Right hand	6	0	7	0	0
Left hand	21	41	66	69	100
Picks up small objects using finger and thumb					
Right hand	0	0	3	8	0
Left hand	100	100	98	93	100
Uses thumb in grasping objects					
Right hand	49	8	21	25	0
Left hand	52	93	80	76	100

Notes: %[1] Percentage of time finger movements were observed during the first 5 minutes of undirected play. Values round up to nearest whole value.

Results show that Bob can grasp and hold objects with all fingers acting together using both hands. He can pick up small objects using his finger and thumb with both hands, and use both thumbs to grasp objects. Of particular note, is the small incidence of right-hand use to grasp and pick up objects. However, consistent with previous results, Bob demonstrates left hand preference.

The photograph illustrated in Figure 4.5 shows Bob's finger movements during an undirected free play activity.

Figure 4.5 Photograph to illustrate finger movements during play sessions

Manipulating a resource using both hands together[1]

Notes:
[1] Right hand used to assist task – opening a zip using left hand on a plastic wallet.

The final set of results, presented in Table 4.7 focuses on hand-eye coordination. This refers to the coordinated control of eye-movement with hand-movement.

Hand-eye coordination in play sessions

Results show that Bob maintains visual alertness and attention to relevant features of a task. He predominantly looks at his hand when carrying out a task but can also continue with an action without looking at his hand. When grasping objects, the action is mainly visually directed. Bob rarely grasps objects without watching his hand movements.

Table 4.6 Hand-eye coordination in play sessions

Hand-eye coordination	*Weeks*				
	1 (%)[1]	**2 (%)**	**3 (%)**	**4 (%)**	**5 (%)**
Visual alertness[2]	80	98	98	87	98
Attention to hand[3]	82	87	96	86	97
Visually directed grasping[4]	78	91	89	85	68
Reaches for objects[5]	85	100	90	0	0
Grasps[6]	0[7]	0	5	1	0

Notes: %[1] Percentage of time action observed during the first 5 minutes of undirected play. Values round up to nearest whole value.
[2] Visual alertness and attention to relevant features of the task when task requires this
[3] Attention to hand carrying out task when necessary
[4] Visually directed grasping observed (when appropriate to task) Total time percentage
[5] Reaches for object when both hand and object are in view
[6] Grasps when just object is in view (hand actions not observed)
[7] Total number of times observed

Figure 4.6 Photograph to show hand-eye coordination during play sessions

[1] Using pincer grip with left hand to stack Numicon pegs

Notes:
[1] Right hand used to stabilise position as Bob leans forwards to stack Numicon pegs with his left hand.

Summary of Results

The results of the typography of movement demonstrated that Bob's motor control was affected by CP but did not inhibit motor tasks. This was because Bob used compensatory strategies to achieve successful outcomes.

As Bob has greater weakness on his right side, it is unsurprising that results consistently demonstrate left side dominance across all of the motor tasks observed. Results did not provide any evidence of a decline in motor performance during each session, or over the five week observation period. When involved in undirected play activities Bob demonstrated high levels of patience, perseverance and determination. This was demonstrated through an independent approach being taken, for example, not asking for assistance and efforts to solve practical challenges through trial and error. Overall, results did not suggest that motor difficulties resulting from CP would impede Bob's attention. As observations did not provide evidence that physical difficulties were affecting attentional capacity the cognitive aspects, presented through on-task and off-task actions were subsequently considered. The pre-intervention assessment to establish the presentation of behaviours follows.

4.5 Pre-intervention assessments: pattern awareness weeks 1- 4

Materials

A selection of practical resources was provided, including: coloured pens and pencils, blank pictures of T-shirts on A4 paper, blank coloured A4 paper, coloured shapes and numbers, digit cards, cuisenaire rods, clothes pegs, Numicon pegs and peg board. The materials were selected to provide a range of familiar resources that Bob was likely to have encountered previously, so that the focus was on pattern rather than exploration of novel objects.

Procedure

The first three sessions were undertaken in the same space outside two classrooms. The same initial procedure was followed: the teaching assistant was present and was requested to observe quietly without intervening. We had our usual chat so Bob could tell me any news before we started the activities. I then explained that we would be doing some activities using different resources so that I could see what Bob found easy and what he found tricky. The camera was positioned on the table so that Bob was in view.

Bob was presented with a series of activities, outlined earlier. These were introduced informally as fun activities so that Bob was unaware he was being assessed. This was to maintain a relaxed environment and to ensure Bob did not feel anxious. The procedure was repeated for pattern awareness activities two, three and four.

Tasks to assess pattern awareness

Table 4.7 provides examples of the activities and timeframe of the pattern awareness activities. Photographic images of the following have been included:

- Identify which two strips of unifix cubes 'go together' when presented with three strips (Figure 4.7).
- Create a row using coloured wooden shapes and copy the row beneath so that the rows 'match' each other (Figure 4.8).

Figure 4.7 illustrates a pattern awareness task. Motor movement shows that Bob maintains upper body control whilst using both hands to hold and compare two of the strips. His left elbow and right wrist are positioned on the table for stability. Bob has positioned the end of the non-alternating strip on top of his right hand.

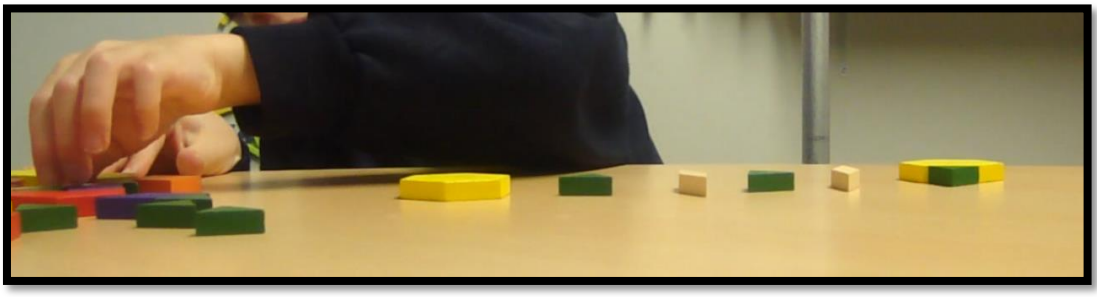
Figure 4.7 Task to assess pattern awareness: To identify which 2 strips of unifix cubes 'go together'.

[1]

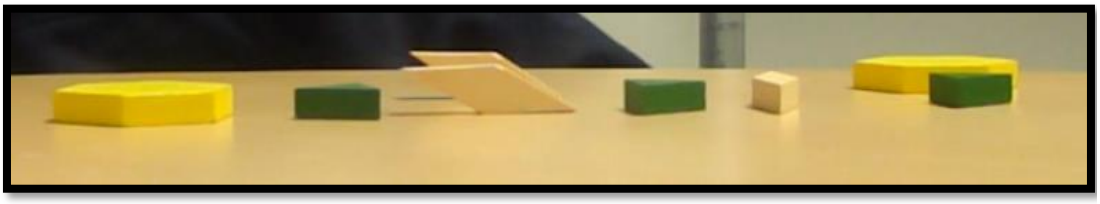
Notes: [1]
The strips comprise two different coloured cubes. Two strips are arranged in an alternating pattern.

Figure 4.8 Task to assess pattern awareness: To devise a pattern and copy it

1



2



Notes:
[1] Although resources are positioned to the right-side, Bob leans over to access them using his left hand. The right hand is used to stabilise his upper-body.
[2] Bob describes the green triangle and yellow hexagon as a house. He changes the placement of the two beige shapes to create a peacock.

Table 4.7 Pattern awareness activities week 1-4

Timeframe	Phase (A[1])	Activities
2/11/15	Pattern awareness-activities 1	Make patterns from different practical resources. Use coloured pens to create patterns on blank pictures of T-shirts. Continue patterns started by the researcher using coloured shapes and digit cards.
09/11/15	Pattern awareness-activities 2	Use coloured pens to draw patterns on blank pictures of T-shirts. Match[1] identical strips of unifix cubes arranged in alternating patterns using two colours. Make a pattern using coloured unifix cubes. Complete different patterns started by the researcher using shapes and numbers.
19/11/15	Pattern awareness-activities 3	Draw patterns using coloured pens and paper. Match identical strips of unifix cubes arranged in alternating patterns using two colours. Make a pattern using coloured unifix cubes. Complete different patterns started by the researcher using shapes and numbers.
23/11/15	Pattern awareness-activities 4	Complete different patterns started by the researcher using shapes and numbers. Match identical strips of unifix cubes arranged in alternating patterns using two colours. Make a pattern using coloured wooden shapes/unifix cubes. Match identical two rows of numbers from three.

Notes:
Match[1] Use of researcher language was planned to check understanding of concepts as well as vocabulary.

Results

Based upon what Bob was able to demonstrate both practically and verbally the following inferences were made:

- Bob's ability to see pattern is dependent upon the visual presentation.
- Physical gaps between shapes are crucial.
- Patterns made on the table need to be presented in a single horizontal row.
- Bob recognises that some shapes are the same and can sometimes select a shape to match another one.
- Bob has difficulty articulating his reasoning, for example when asked to say what is different about an alternating blue and white pattern, he says, 'because they've both got the same colours', suggesting that he may be aware of a pattern but is unable to articulate why.
- Understanding key language, for example, 'repeating' and 'continue' is not always demonstrated.
- Bob's perception of pattern is articulated as 'lots of' different colours Figure 4.9 shows the 'pattern' constructed by Bob. This comprises different coloured cubes arranged in a random order.
- Bob is unable to continue a pattern independently. When continuing a pattern, his justification for choice of next shape is based on 'looking nice'.
- Bob shows understanding of pattern when he hears it voiced, for example, "red, wood, red, wood…" When hearing a pattern aurally, Bob can, with prompts, select the relevant shape and position it in a row from left to right.

As part of the pattern awareness assessment, Bob was asked to draw a pattern on a blank image of a T-shirt on white paper. He was provided with a selection of coloured pens but no illustrations of patterns were provided to help him (Figure 4.10).

Figure 4.9 Pre-intervention session - Pattern awareness week 2

In the following session Bob was provided with a piece of paper and different coloured pens. He was asked to draw a pattern but consistent with the previous week, a visual illustration was not provided as an example. Figure 4.11 illustrates Bob's drawing of a pattern which he completed without anything to model it on. Both drawings show single lines and blocks of colours in non-structured random arrangements. There is no evidence of a repeated design or arrangement following a rule, or recurring sequence. The drawings have been taken as evidence of Bob's conceptual understanding of pattern, prior to the intervention. That is to say, the drawings show no sign of 'a systematic arrangement of numbers, shapes or other elements according to a rule' (DCSF in full, 2009, p. 23).

Figure 4.10 Patterns drawn in Pattern awareness week-2

1

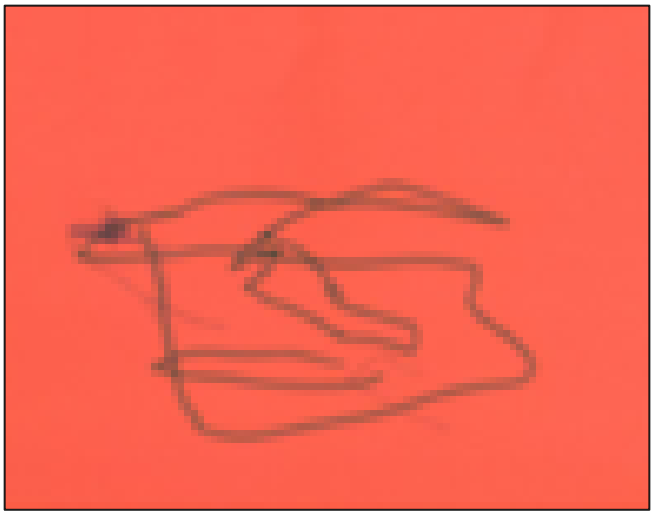
2

Notes:
[1] Bob stabilises the paper using his right hand. He grasps the pen with his left hand. The paper is positioned to his far-right side and he is leaning over towards the right.
[2] Bob's completed pattern. This was constructed by making green marks and dots followed by yellow and pink marks.

Figure 4.11 Bob's 'pattern' drawn in Pattern awareness week 3

1

2



Notes:
[1] Bob stabilises the paper using his right hand. He holds the pen with his left hand using a pincer grip.
[2] Bob's completed pattern. This was constructed by drawing the inner shape, two horizontal lines left to right and right to left and a continuous line around the inner shape.

4.6 Coding of on-task and off-task actions

The recorded observations undertaken of 1) Bob playing with equipment without any researcher intervention and 2) additional researcher directed sessions using pattern as a focus, were used to gain an understanding of the presentation of on-task and off-task behaviours in both undirected and directed sessions. This was important so that a chart could be devised with coded behaviours, specific to Bob, to use as a measure for the assessments and throughout the Intervention.

The following definitions were used to describe behaviours characteristic to Bob, given his motor impairment:

- On-task - having direct involvement with the intended task
- Off-task - lack of engagement with the intended task.

Procedure

From drawing upon extensive practitioner experience I devised an initial list of behaviours which were representative of engagement within a mainstream classroom. I watched the video recordings of the observations and looked for any additional behaviours which were characteristic to Bob. The undirected free activity play sessions provided scope to ascertain an accurate picture of Bob's behaviours when he was engaged in play. Similarly, because the sessions were undertaken in an area susceptible to interruptions it provided scope to see behaviours associated with distractibility. When the on-task behaviours had been established a simple researcher devised recording sheet was used to observe and code the video footage in consecutive five second intervals. The recordings were played repeatedly and all on-task behaviours ticked.

Table 4.8 Sample taken from the on-task and off-task behaviour recording sheet

Observer:	**Sheet Number**				**Context**							
Time frame (seconds)	• On-task = ✓ • Off-task = x											
0-59 Secs	**0-5**	**6-10**	**11-15**	**16-20**	**21-25**	**26-30**	**31-35**	**36-40**	**41-45**	**46-50**	**51-55**	**56-59**

Table 4.9 provides a list of all on-task behaviours observed and recorded during the pre-intervention assessments. 'Y' was chosen to represent 'Yes', on-task.

Table 4.9 Key to coding of on-task behaviours

Coded Behaviour	On-task behaviours[1] Definition
Y	**On-task**
	Responding to questions
	Following instructions
	Asking for help with the task
	Using resources appropriately to undertake directed tasks
	Scanning resources to select what is required for the activity
	Reaching and grasping resources needed for a task
	Looking at the researcher when the researcher explains a concept and demonstrating listening by nodding at appropriate times
Y(Y)	Yawning but focus maintained
Y(E)	Engrossed in task but not responding to questions

Notes: Behaviours[1] were observed at least once during the pre-intervention sessions.

When the recording sheet had been completed the video recordings were replayed and stopped when on-task behaviours were not evidenced. The observed behaviour was written down to create a list which informed the creation of off-task codes, characteristic to Bob. Table 4.10 shows the list of all behaviours that were evidenced during the pre-intervention assessments. 'X' was used to denote 'off-task' and a letter of the alphabet assigned after. Similarly, 'F' was associated with off-task behaviours due to focus and 'I' assigned to interruptions to the activity which resulted in off-task behaviours.

Table 4.10 Key to coding of off-task behaviours

Coded Behaviour	Off-task behaviours[1] Definition
X	**Off-task**
X(a)	Looking away from the equipment during a task, when visual attention required
X(b)	Looking away from the activity and/or not responding to a direct question
X(c)	Humming and/or playing with equipment during direct instruction
X(d)	Ignoring a question and fiddling with equipment
X(e)	Looking away from the researcher and/or whistling, when listening is required
X(f)	Bouncing up and down in chair, flapping arms about, moving head from side to side repetitively
X(g)	Not responding to an instruction to carry out a task, and making sound effects
X(h)	Saying 'done' or 'I'm not doing that' before the session has completed
X(i)	Gazing around the room
X(j)	Asking questions or making conversation unrelated to the task
X(l)	Resting head on table and not looking at the activity when visual attention required
X(k)	Sucking clothing/lunch wrist band and not responding to questions
F	Behaviours which affect **focus**
F(Y)	Yawning
F(B)	Upper body posture slumped
F(H)	Head resting on table
F(R)	Rubbing eyes
Z	Bob appears 'zoned out' for no apparent reason
I	**Interruptions** which affect focus
I(N)	Environmental noise
I(A)	Adult entering space
I(P)	Child(s) entering space

Notes: Behaviours[1] were observed at least once during the pre-intervention pattern awareness sessions.

The on-task and off-task charts illustrated typical behaviours, specific to Bob and were used as a measure of attention across the intervention. This was achieved by coding 'learning-relevant' behaviours on the recording sheets for the first twenty minutes of each assessment at consecutive five second intervals.

In addition to the on-task and off-task recoding sheet, a similar recording sheet was used for the purpose of recording every prompt provided by the researcher.

A completed example can be seen in appendix four, page 258. Prompts were recorded as ‘P’. The number of prompts recorded refers to verbal intervention provided specifically to re-focus Bob’s attention when off-task. Prompts included: repetition of instructions, pointing to resources to encourage visual attention, questions or statements to acknowledge an action carried out, or repeating Bob’s name to gain his attention.

4.7 Summary

This chapter has provided an overview of the background to the case, including the observations undertaken of Bob in his daily school activities and an appraisal using Numicon. The materials, procedure and results were presented for the pre-intervention assessments that were an integral part of the present study. The following chapter provides an account of the intervention sessions.

Chapter 5: Intervention

5.1 Introduction

This chapter describes the intervention sessions, taught weekly for three cycles. Table 3.1, page 71, shows the details and time-line of the intervention including the withdrawal periods and assessments.

5.2 Cycle One

Design

Week one

The activities were designed to help Bob see patterns in number relationships by ordering the Numicon shapes[54]. (See Figure 3.1, page 73 for pictorial images of Numicon). The discussion about the patterns focused on odd and even numbers in alternating patterns from number one to ten.

Independent variables:

- ABAB pattern (alternating odd and even)
- Sequences (increasing and decreasing in increments of one)

Week two

The session was designed firstly, to recap activities from week one, so that an assessment could be undertaken to check for retention and understanding, and secondly, a series of new tasks were introduced. The concept of an alternating pattern, introduced in week one, was repeated in a different context to generalise learning.

Weeks three and four

The aim was to reinforce the concepts covered in the first two weeks. Previous tasks were repeated and one new task was introduced in week three: Task 3.
Independent variables:

- Alternating ABAB pattern (red/yellow; green/blue)
- Continuation of AAB pattern (red, red, yellow)

[54] Each Numicon shape represents a different number.

- Increasing and decreasing number patterns
- Alternating ABAB pattern (odd and even).

Materials

The Numicon resources were used for the tasks covered in this phase. The differing number reflected the length of time Bob needed to complete them, since session times were of equal length. The materials most familiar to Bob were the ones chosen. The Numicon pegs and peg boards were used to introduce the term 'alternating' pattern using two different colours. Digit cards were provided to match the Numicon shapes to corresponding numbers.

Procedure

Week one

Bob was asked to place the Numicon shapes in order of size, first of all starting with the smallest and then repeating with a new set of Numicon shapes, starting with the largest. Once the shapes had been positioned in the correct order Bob was asked what he noticed.

In subsequent sessions Bob was asked what he remembered from the previous session and prompted to say any new words learned before subsequent tasks were introduced. Details and a time-line of the first cycle of sessions are presented in the following tables 5.1 to 5.4. Table 5.5 shows the timeframe of the withdrawal and second assessment.

Table 5.1 Details and time-line of the sessions: Cycle 1 week 1

Timeframe	Activities	Description	Language and concepts
18/01/16	1	Placing the Numicon shapes 1-10 in a horizontal numerical row starting with 1 and finishing with 10	Number pattern
	2	Look at the odd and even Numicon shapes. What do we notice about Numicon shapes 3 5 7 and 9?	Odd/even pattern
	3	Ordering the Numicon shapes from largest to smallest	Looking at visual aspects of a pattern: smallest to largest, largest to smallest.

Table 5.2 Details and time-line of the sessions: Cycle 1 week 2

Timeframe	Activities	Description	Language and concepts
25/01/16	1	What do we remember from last week?	recall of 'pattern'
	2	Recap of odd/even	odd/even
	3	Match the corresponding Numicon-shapes 1-10 to a digit card.	
	4	Make an odd/even pattern starting with number 1	odd/even
	5	Researcher demonstrates an alternating pattern using red/yellow Numicon-pegs on a peg-board. Bob copies the pattern on a separate peg board. Activity repeated with green/blue pegs.	alternating odd/even pattern alternating pattern with colours
	6	Continue a pattern started by the researcher, using the pegs (red/red/yellow, red/red/yellow).	AABAAB pattern
	7	Make a pattern with the Numicon shapes starting with the biggest shapes	one less odd/even

Table 5.3 Details and time-line of the sessions: Cycle 1 week 3

Timeframe	Activities	Description	Language and concepts
01/02/16	1	What do we remember from last week?	Recall of 'pattern'
	2	Recap of concepts covered last week.	Alternating odd/even Increase/decrease by one
	3	Using pegs and peg-board, researcher makes Numicon-shapes. Bob to find Numicon-shapes that matches pattern.	Patterns in shapes
	4	Make an odd/even pattern starting with number 1.	Odd/even pattern
	5	Researcher makes a pattern on the peg-board using Numicon-pegs. Bob copies on a second board.	Alternating pattern with colours
	6	Bob to make an alternating pattern using two different coloured pegs.	Same/different

Table 5.4 Details and time-line of the sessions: Cycle 1 week 4

Timeframe	Activities	Description	Language and concepts
08/02/6	1	Using two different coloured Numicon-pegs, create an alternating pattern, in a row on the peg-board.	Reinforce concept of a 'row' Alternating
	2	Make an odd/even number pattern starting with number 1.	Odd/even. Increase pattern by one Smallest/largest.
	3	Make patterns on the peg-board using coloured Numicon-pegs.	

Table 5.5 Details and time-line of the withdrawal of the sessions and second assessment (T2)

Timeframe	Activity
15/02/16 22/02/16	Withdrawal[1]
29/02/16	Assessment T2

Note:

[1] No intervention activities or pattern work during daily school activities.

5.3 Cycle two

Design

Cycle two commenced the week following the second assessment (T2). Following my practitioner reflections these sessions were modified because it was apparent that the work needed to be targeted at a much lower level. All number work was removed and a focus on alternating pattern, using colour and shapes, formed the basis of all sessions. I also attempted to simplify the language used to minimise processing demands. The ABAB pattern was therefore repeated throughout the session, using the same resource with different colours, or a different resource, to increase variety.

Tasks undertaken in week two, provided opportunities to reinforce the concept of an alternating ABAB pattern using different resources. Tasks in week three were designed to provide further opportunities to consolidate learning of a simple ABAB alternating pattern through repetition. As playdough proved motivating and fun, the activities predominantly revolved around this resource; Bob was invited to select the colours and shapes to increase his sense of involvement. A new ABCD pattern was introduced and the variable changed in Task 6 to increase the level of difficulty.

Independent variables across cycle two

Week one:

- Alternating ABAB pattern (combinations of two different colours)
- Alternating tall and short ABAB pattern (same colour)
- Alternating ABAB pattern with two different shapes (same colour)

Added for week two:

- Alternating ABAB pattern two shapes (two colours)

Added for week three:

- Extending the pattern to include two shapes (same colour), repeated by two shapes (different colour)
- Copying a pattern using a different medium.

Materials

Resources that had previously been used, including the Numicon shapes and unifix cubes were used to provide familiarity and consistency, in addition to new resources introduced into the sessions to add variety whilst repeating the same concept. It was hoped that differing the resource would help maintain interest despite the level of repetition. New resources included: coloured wooden blocks and coloured plastic counters. cuisenaire rods provided during pre-intervention undirected play were incorporated to avoid the introduction of too many new resources. (Figure 7.3, page 171 shows Bob using cuisenaire rods to copy an alternating ABAB pattern created with the playdough). Playdough was introduced in week two, a) to ascertain whether the increased time needed to physically make the resources helped with processing of concepts, and b) to see if physically manipulating the playdough increased attention and motivation.

Procedure

The procedure described for the start of previous sessions was replicated, including questions to check Bob's recall and memory of previous learning and the term, 'alternating pattern'. The new tasks were then introduced in the order presented in tables 5.6, 5.7 and 5.8. Cycle two was followed by the withdrawal phase. This consisted of three weeks rather than two due to the practicalities of fitting it around the Easter holiday period. Table 5.9 shows the timeframe of this and subsequent assessment T3.

Table 5.6 Details and time-line of the sessions: Cycle 2 week 1

Timeframe	Activities	Description	Language and concepts
07/03/16	1	Questions about previous session to check recall and memory of terms	Alternating pattern
	2	Continue patterns started by the researcher using a range of different colours/resources: red/yellow, blue/green, purple/orange (wooden blocks) green/red, orange/blue (plastic counters)	Repeating pattern
	3	Bob to construct an alternating pattern using yellow/purple counters (unsupported to assess understanding).	Generalise using different variables
	4	Make a 'repeating' pattern using Numicon shapes	
	5	Make an alternating pattern using unifix cubes: green/purple red/yellow	
	6	Copy a pattern using cuisenaire rods	

Table 5.7 Details and time-line of the sessions: Cycle 2 week 2

Timeframe	Activities	Description	Language and concepts
14/03/16	1	Sort yellow unifix cubes into two piles (short/tall)	Alternating short/tall pattern
	2	Use above to make an alternating pattern	ABAB blue/yellow pattern
	3	Repeat tasks using blue then orange cubes	
	4	Make an alternating pattern using 6 strips of unifix cubes - same length/two colours (blue/yellow)	
	5	Make sausages and balls out of yellow playdough	ABAB sausage/ball pattern
	6	Make an alternating pattern comprising sausage/ball Repeat using blue playdough	Change variable (colour)
	7	Make an alternating pattern using Numicon shapes 1 and 10	Change variable (texture, colour, number-shape)

Table 5.8 Details and time-line of the intervention: Cycle 2 week 3

Timeframe	Activities	Description	Language and concepts
21/03/16	1	Make an alternating tall and short pattern using blue unifix cubes	Alternating short/tall pattern
	2	Make sausages and balls out of red playdough	ABAB pattern
	3	Make an alternating pattern comprising sausage/ball	Change variable (shape/colour)
	4	Make blue sausages. Make an alternating blue/red sausage pattern	
	5	Continue/repeat a pattern started by the researcher (blue ball, blue sausage, red ball, red sausage)	ABCDABCD pattern
	6	Copy the above pattern using cuisenaire rods	Change variable (colour, texture and shape)

Table 5.9: Cycle 2: Details and time-line of the withdrawal of the sessions and third assessment (T3)

Timeframe	Activity
29/03/16 04/04/16 11/04/16	Withdrawal[1]
18/04/16	Assessment T2

Note:

[1] No intervention activities or pattern work during daily school activities.

5.4 Cycle three

These sessions were designed to provide further opportunities to consolidate previous learning through repetition and practise of alternating ABAB patterns. In addition, the concept of pattern was expanded and new resources introduced during the first week. The level of instructions gradually increased in difficulty, and a rule was introduced in week two to assess Bob's understanding when problem solving skills were needed for a task.

Task 2 (see Table 5.10, page 131) was designed to develop the ABAB pattern to an extended ABCABC pattern. Further cognitive challenge was implemented in Task 3, and the pattern was changed to AABAAB. The objective of Task 7 was to see if Bob could add a third element to an alternating pattern without support. This was designed to assess whether there had been any generalisation of the pattern concept.

Week three included tasks which created a higher level of challenge and problem-solving skills. The alternating ABCABC pattern was repeated (Task 5), and rules provided for other patterns.

Independent variables

- Alternating ABAB pattern (combinations of two different shapes in different colours)
- Alternating ABC pattern (three different shapes in different colours)
- Introducing a change in the pattern AABAAB

Added for week two

- Introduction of a rule (for example, triangles and squares always go together)

Added for week three

- Bob to make a pattern using three different lengths of cuisenaire rods in three colours.

Materials

New resources including, Fimo modelling clay[55] and magnetic shapes were introduced to provide variety and also to assess whether a different medium

[55] Shapes were pre-made by the researcher and baked in the oven until hard.

would alter attention levels. This was an important consideration in providing post-intervention advice and recommendations.

The plastic, red magnetic shapes were introduced and positioned inside a metal tray. The purpose was to assess if the option of sliding shapes would reduce the fine motor demands of picking shapes up and re-positioning them. Task 3 was unplanned before the session, but added to re-engage Bob's interest with a familiar activity, following disruption to the session due to an unplanned school evacuation.

Some tasks were designed to enable Bob to choose his own materials, for example, which playdough cutter shapes and colours he wanted to use. The rationale was to see if this increased engagement. In addition, time spent making the resources provided a relaxed opportunity for discussion about the activities.

Procedure

The same procedure for starting the session was followed as described previously. Questions were then asked about the preceding session and types of patterns made to establish learning and recall of concepts. Bob demonstrated understanding verbally by describing the patterns. Examples of this have been taken from intervention three: week three and included:

- "Sausage, ball, sausage, ball….until it gets to the end"
- "Long, short, long, short."

The tasks were then introduced in the order shown in the following tables.

Table 5.10 Details and time-line of the sessions: Cycle 3 week 1

Timeframe	Activities	Description	Language and concepts
25/04/16	1	Questions about previous session. What patterns did we make?	
	2	Make an alternating pattern using different shapes: pink ducks / green birds; pink duck / green bird / brown dog	ABAB pattern ABCABC pattern
	3	Choose shapes and make an alternating pattern for the researcher to copy (dog/bird)	ABAB pattern
	4	Continue/repeat a pattern started by the researcher (duck, duck, bird, duck, duck, bird)	AABAAB pattern
	5	Bob to choose a playdough cutter (dog, butterfly, bird or elephant) and playdough colour (white, yellow, red or blue). Bob to roll out the playdough and cut four elephant shapes. (Researcher to make four ducks)	ABAB pattern (change variable: texture)
	6	Bob to make an alternating pattern using the red elephants and red ducks.	ABAB pattern (same colour/two shapes)
	7	Bob to choose three colours from the box of cuisenaire rods. Then make a pattern using the chosen rods	

Table 5.11 Details and time-line of the sessions: Cycle 3 week 2

Timeframe	Activities	Description	Language and concepts
03/05/16	1	Using magnetic shapes on a magnetic board, sort into different groups: 4 red triangles, 4 red squares, 4 red circles, 4 red rectangles.	Sorting
	2	Make a pattern using the shapes. Rule: triangles and squares must always 'go together'.	Introduce a rule to pattern
	3	Make an alternating pattern using purple butterflies and white elephants.	ABAB pattern
	4	Re-sort magnetic shapes into groups.	
	5	Make a pattern. Rule: always have the circles and squares 'next door' to each other.	

Table 5.12 Details and time-line of the sessions: Cycle 3 week 3

Timeframe	Activities	Description	Language and concepts
09/05/16	1	What can Bob tell researcher about pattern?	Assessment of learning
	2	Using magnetic shapes on a magnetic board, sort into different groups: 4 red triangles, 4 red squares, 4 red circles, 4 red rectangles.	
	3	Use all of the shapes to make a pattern in a row. Rule: always have a square and circle together.	
	4	Bob to choose 2 shapes from: purple rectangles, blue circles, green triangles and pink squares. Make an alternating pattern with them.	Alternating pattern
	5	Bob to add purple rectangles to a pattern started by the researcher; blue circle/green triangle	ABCABC pattern
	6	Add pink squares to the pattern. Rule: Keep the blue circles and green triangles together.	
	7	Add other shapes to the pattern. Rule: Keep the blue circles and green triangles together.	

Table 5.13 Cycle 3: Withdrawal of the intervention and post-intervention assessment (P1)

Timeframe	Activity
16/05/16	No intervention activities by researcher. No pattern work during daily school activities.
23/05/16	
30/05/16	
6/07/16	Post-intervention assessment (P1)

5.5 Summary

This chapter has provided an account of the intervention including the timeframes for the sessions, order and details of the activities and the timings of the withdrawal periods and assessments. Chapter 6 provides details of the baseline and initial post intervention assessments T1, T2 and T3.

Chapter 6: Baseline and initial post-intervention assessments

6.1 Introduction

In what follows the materials and procedure for each post-intervention assessment are described followed by the assessments themselves. A comparison of the results of the assessments across each cycle of the intervention is provided in Chapter 8. The purpose of the assessments was to find out if the intervention led to increased attention and other improvements in Bob's performance of the tasks.

6.2 Assessment T1

The purpose of this first assessment was to determine if Bob showed any awareness and understanding of pattern and to establish baseline level. This idea presupposes that without intervention behaviour would remain the same. It would also remain the same if the intervention was ineffective and did not produce change. As the tasks were planned around activities which were not being taught or practised at other times, sustained improvement in attention from baseline levels would suggest the intervention was successful in effecting a stable change.

Repeated assessment used in this single-case design enabled any changes across the intervention to be examined. Different patterns, which incorporated shapes and numbers, to target visual and auditory recognition, were included in the assessment. The opportunity to match patterns enabled Bob to demonstrate pattern awareness without the need to provide a verbal explanation.

Materials

The resources used for this assessment were chosen because Bob had previous experience of them during the pre-intervention assessments. This was important because the dependent variable (time on-task) was being measured as a baseline for the intervention. The purpose of using familiar resources was therefore to minimise distractions arising from novelty. Table 6.1 provides an overview of the aim of each task, and the independent variables and their

properties. This is followed by Table 6.2 which shows the order of tasks and a description of each task.

Table 6.1 T1: Aim, materials and properties

Task	*Design*				
	Aim	**Pattern**	**Resource**	**Features**	**Colour**
1	match	shapes sequence	paper shapes	two-dimensional flexible/smooth	white
2	match	alternating ABAB	unifix cubes	three-dimensional Inflexible	blue/white
3	match	number sequence	paper	two-dimensional	black on white
4	continue	number sequence	Numicon shapes	three-dimensional Inflexible	orange/blue
5	match	alternating ABAB	unifix cubes	three-dimensional Inflexible	pink/purple
6	match	number sequence	digit cards	two-dimensional flexible/smooth	black on white
7	continue	alternating ABC	wooden shapes	three-dimensional Inflexible	yellow, purple, red

Table 6.2 Details and time-line: T1

Timeframe	Task	Description
30/11/2015	1[1]	To identify which two rows of white two-dimensional shapes 'match' when presented with 3 horizontal rows, one on top of the other (top and middle row = circle, triangle, triangle, square, circle. Bottom row = triangle, circle, triangle, triangle, square).
	2	To identify which two strips of unifix cubes 'go together' when presented with 3 strips comprising blue and white colours. Matching strips arranged in an alternating blue and white pattern.
	3	To identify which two rows of numbers 'match' when presented with 3 horizontal rows of digits 1-9 in non-sequential order (top and bottom rows match).
	4	To continue a pattern started by the researcher, using Numicon shapes one and two. The row is presented horizontally left to right (one, one, two, one, one and two).
	5	To identify which two strips of unifix cubes 'go together' when presented with 3 strips comprising pink and purple colours. Matching strips arranged in an alternating pink and purple pattern.
	6	To identify which two rows of digit cards 'match' when presented with 3 horizontal rows (top and bottom = 1,2,3,4,5,6. Middle = 1,6,5,3,2,4).
	7	To continue a pattern started by the researcher using coloured wooden shapes presented in a horizontal row, left to right (yellow hexagon, purple diamond, red parallelogram, yellow hexagon, purple diamond, red parallelogram).

Notes: Task 1[1] Tasks presented during pattern-awareness weeks 1-4 repeated for T1.

Procedure

The assessment took place in a quiet meeting room to minimize the effect of situational variables such as noise or interruptions. The same procedure was followed as described for pattern awareness activities two, three and four. Repetition of previous activities ensured that Bob had previously experienced the motor movements needed and that lack of familiarity did not impede his performance.

T1 Results

The results of numerically based tasks undertaken during T1 and T2 have not been included because, as previously reported, it was observed that Bob did not have a secure understanding of number as a concept. Those observations indicated that Bob could count by rote to ten but not consistently and when starting from a number greater than one the sequence became muddled. Bob was unable to demonstrate one-to-one number correspondence[56] and he was unable to match visual representations of numbers to that articulated. In subsequent tasks, therefore, number pattern was removed from the intervention and the focus was on non-numerical patterns varying according to material, colour, shape, size and texture.

The first set of results that follow include:

- Actions (looking, handling and speaking)
- On-task and off-task behaviours.

Bob's behaviours during activities (actions) were coded because an improvement in task performance could be observed alongside a decrease in engagement. It was therefore necessary to demonstrate that any changes in performance, following the intervention, were correctly interpreted.

There is variance in numbers of tasks shown for each set of results because actions were coded for the first fifteen minutes, whereas on-task behaviours were coded for the entirety of each assessment. A timeframe of fifteen minutes, to code and compare actions across assessments, seemed

[56] Number of objects counted did not match the number articulated.

appropriate in light of Bob's motor impairment and possible muscular pain and fatigue associated with CP. The coding of on-task and off-task behaviours for all tasks provided a measure to ascertain if attention was improving over time regardless of task performance. To guard against training and other order effects, the order of tasks was systematically varied.

Tasks 1-7

Description of tasks: coded for actions and on-task and off-task behaviours (first 15 minutes)

Task 1 (Looking): To identify which two rows of white two-dimensional shapes 'match' when presented with three horizontal rows, one on top of the other (top and middle row: circle, triangle, triangle, square, circle. Bottom row: triangle, circle, triangle, triangle, square).

Task 2 (Looking): To identify which two strips of unifix cubes 'go together' when presented with three strips comprising blue and white colours (matching strips are arranged in an alternating ABAB blue and white pattern).

Task 3 (Looking): To identify which two rows of numbers 'match' when presented with three horizontal rows of digits 1-9 in non-sequential order (top and bottom rows match).

Task 4 (Handling): To continue a pattern started by the researcher, using Numicon shapes one and two. The row is presented horizontally left to right: one, one, two, one, one, two.

Task 5 (Looking): To identify which two strips of unifix cubes 'go together' when presented with three strips comprising pink and purple colours (matching strips arranged in an alternating ABAB pink and purple pattern).

Task 6 (Looking): To identify which two rows of digit cards 'match' when presented with three horizontal rows (top and bottom: 1,2,3,4,5,6. middle: 1,6,5,3,2,4).

Task 7 (Handling): To continue a pattern started by the researcher using coloured wooden shapes presented in a horizontal row, and ABCABC repeating pattern. Left to right: yellow hexagon, purple diamond, red parallelogram…

Table 6.3 provides an overview of looking and handling actions observed during T1.

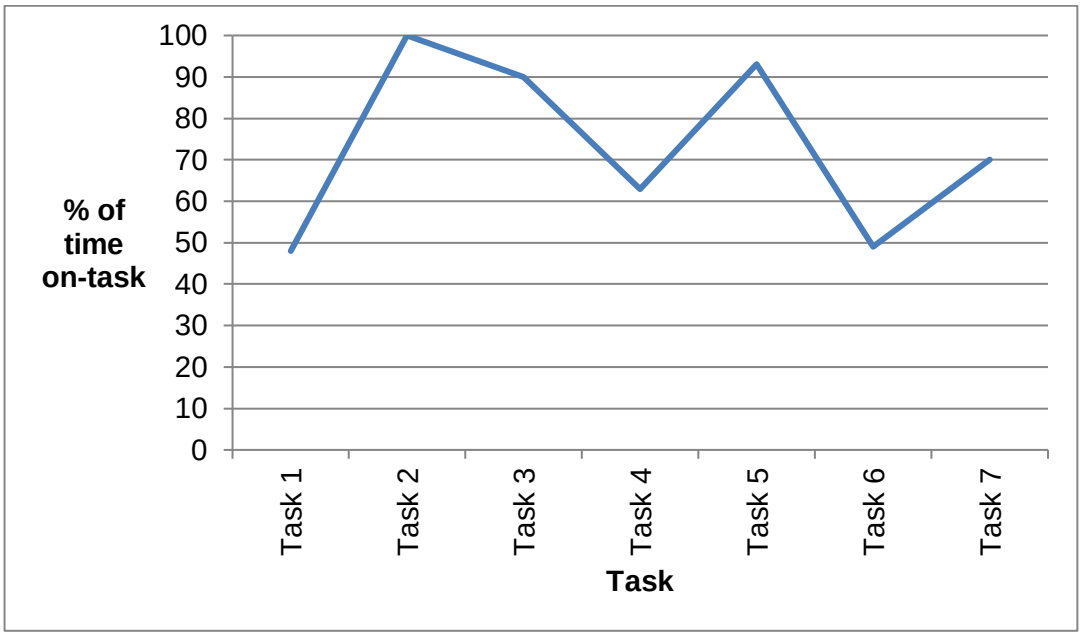
Table 6.3 T1: Percentage of time actions were observed during the first 15 minutes of assessment.

Action	*Tasks score*						
	Task 1 Looking [1] (%)	**Task 2 Looking (%)**	**Task 3 Looking (%)**	**Task 4 Handling [2] (%)**	**Task 5 Looking (%)**	**Task 6 Looking (%)**	**Task 7 Handling (%)**
Looking Object	50[3] (39/78[4])	77 *(13/17)[5]*	**100** *(7/7)*	**69** *(11/16)*	77 *(13/17)*	89 *(8/9)*	**97** *(26/27)*
Researcher	21 *(16/78)*	12 *(2/17)*	15 *(1/7)*	13 *(2/16)*	24 *(4/17)*	23 *(2/9)*	23 *(6/27)*
Handling Pointing-at	12 *(9/78)*	24 *(4/17)*	0 *(0/7)*	0 *(0/16)*	0 *(0/17)*	23 *(2/9)*	4 *(1/27)*
Reaching-towards	3 *(2/78)*	0 *(0/17)*	0 *(0/7)*	0 *(0/16)*	0 *(0/17)*	0 *(0/17)*	0 *(0/27)*
Handling-both hands	2 *(1/78)*	18 *(3/17)*	15 *(1/7)*	7 *(1/16)*	6 *(1/17)*	0 *(0/17)*	0 *(0/27)*
Handling-right hand	9 *(7/78)*	**36** *(6/17)*	0 *(0/7)*	0 *(0/16)*	0 *(0/17)*	**34** *(3/9)*	8 *(2/27)*
Handling-left hand	45 *(35/78)*	41 *(7/17)*	**72** *(5/7)*	32 *(5/16)*	42 *(7/17)*	45 *(4/9)*	**56** *(15/27)*
Speaking Speaking	20 (15/78)	65 (11/17)	**72** (5/7)	32 *(5/16)*	18 *(3/17)*	78 *(7/9)*	***71*** *(19/27)*
Vocalising	5 (4/78)	0 (0/17)	15 (1/7)	19 *(3/16)*	12 *(2/17)*	0 *(0/17)*	*23 (6/27)*

Notes:
Looking-task[1] Tasks dependent upon looking, as the predominant action, for successful completion.
Handling-task[2] Tasks dependent upon handling, as the predominant action, for successful completion.
%[3] Percentage of total time action was observed during task. Values round up to nearest whole value.
(39/78[4]) Numerator denotes number of times same action observed within an event. Denominator represents total number of events within each consecutive 10 second timeframe.
(13/17)[5] Range for each action coded. Number of times action was observed out of total number of events observed across the task. (Events refer to the series of actions observed within a ten second timeframe).

Figure 6.1 shows the total amount of time on-task for each task during T1. This is followed by a detailed breakdown of off-task behaviours using the categories established during the pre-intervention assessments.

Figure 6.1 T1: The percentage of time Bob was attending to the task (measured by on-task behaviours)



The following chart provides a breakdown of all off-task behaviours recorded throughout T1.

Figure 6. 2 Off-task behaviours during T1

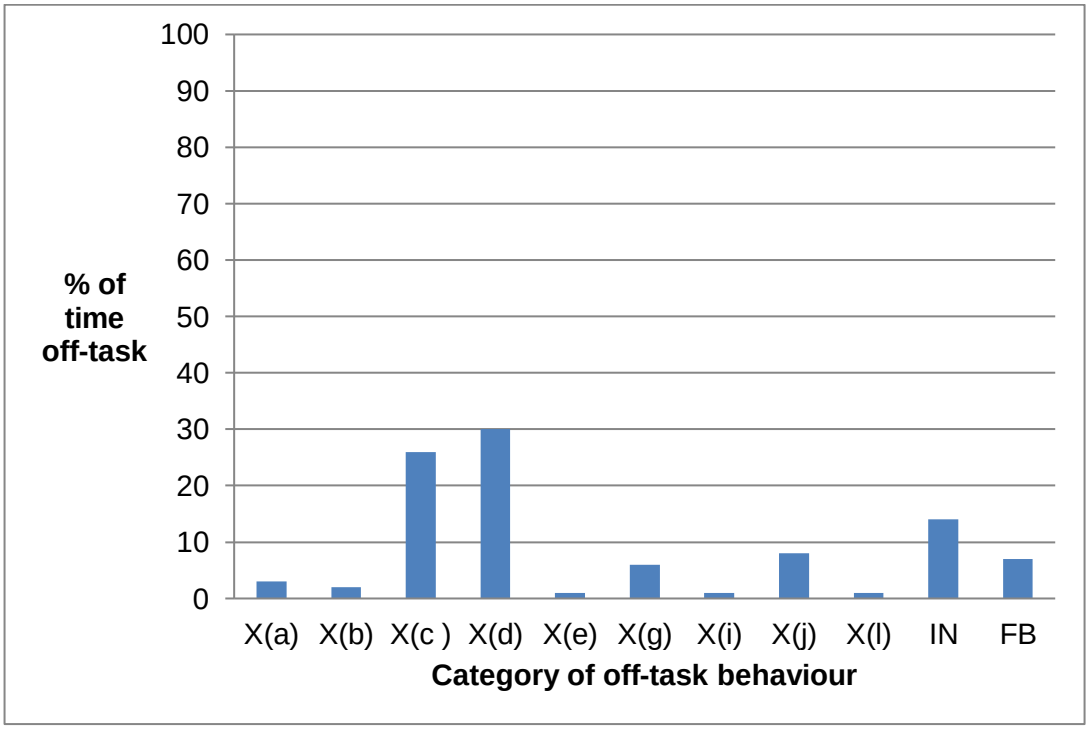


Table 6.4 Off-task behaviours observed in T1

Coded Behaviour	Off-task behaviours[1] Definition
X	**Off-task**
X(a)	Looking away from the equipment during a task, when visual attention required
X(b)	Looking away from the activity and/or not responding to a direct question
X(c)	Humming and/or playing with equipment during direct instruction
X(d)	Ignoring a question and fiddling with equipment
X(e)	Looking away from the researcher and/or whistling, when listening is required
X(g)	Not responding to an instruction to carry out a task, and making sound effects
X(i)	Gazing around the room
X(j)	Asking questions or making conversation unrelated to the task
F	**Behaviours which affect focus**
F(B)	Upper body posture slumped
I	**Interruptions which affect focus**
I(N)	Environmental noise

Note: Behaviours[1] were observed at least once during T1

Analysis of data

The data presented for T1 shows that handling objects was consistent across all tasks, regardless of the main action required. Of note, when the task was classified as a handling-task, the percentage of time handling was not higher than for tasks classified as looking tasks. Attention is drawn to Task 2 and Task 6 because although the main action needed is looking, Bob's right hand use is high. This shows that when using different equipment Bob can plan how to access both the physical and visual aspects of tasks. Task 3 is equally noteworthy due to the high levels of handling evidenced even when Bob's visual attention is focused on the object. This suggests that Bob will change the placement and orientation of objects so he can see them clearly and suggests cognitive advance.

Off-task behaviours were highest during Task 1 and Task 6. What is interesting is that the visual presentation was the same for both tasks (an array displayed in three horizontal rows). Task 8 involved the highest level of cognitive demand (construct and copy) but off-task behaviours observed were

less than those observed during Task 1. On-task behaviour was highest for Task 2 (blue/white unifix) and slightly lower for Task 5 (pink/purple unifix). This suggests repetition did not improve performance. The variable is colour and this may have been of importance, as blue and white provides good colour contrast.

Bob did not speak during Task 2 and Task 6. Of note, whilst both were classified as looking tasks, the percentage of time handling was comparable for each type of handling action. Across the assessment, a total of 56% of off-task behaviours were due to playing and fiddling with resources. As shown in Figure 6.2, 15% of off-task behaviours appeared to be in response to environmental noise. During the assessment a piano was audible and caused a distraction.

Summary

- Actions required for successful task completion did not affect the level of engagement. On-task behaviour was highest and lowest during looking tasks.
- Repetition of the same task did not increase success.
- Length of time to do the task did not increase the percentage of off-task behaviours.
- Off-task behaviour was not at the highest during the most cognitively demanding task.

From the results of the typography of movement, Bob only used his right hand when it was needed for two handed activities. The results for T1 show that handling-both-hands occurred for 36% and 34% of the time in Tasks-2 and Task 6 respectively. This may suggest that his attention on handling actions took priority over speaking, although pointing-at was highest for both tasks compared to all others. This is relevant because pointing may have been used to communicate rather than using language.

Interpretation of T1

Increased engagement, measured by percentage of time on-task, was higher when Bob demonstrated some understanding of the concept (established

through practitioner judgement). A transcript and commentary can be seen in appendix six, page 262).

Task 1 and Task 6 were similar in visual presentation and involved matching two horizontal rows of white two-dimensional shapes or digit cards out of three rows. Off-task behaviours were highest for Task 1 and Task 6 which as highlighted were similar. This could be due to several factors including, firstly, an inability to make visual sense of the task, secondly, not understanding the language used and finally, poor physical positioning.[57] For example, 29% of off-task behaviours across the assessment resulted from poor postural control. To summarise, engagement was highest for Task 2. The resource used for this task incorporated two highly contrasted colours, non-pliable material and an alternating ABAB pattern. The task involved visually discriminating between same and different and whilst not cognitively demanding, required understanding of the task instructions and vocabulary used by the researcher.

The results of T2 are presented next. Some elements were changed for example, the order of identical tasks undertaken in T1 to determine if possible fatigue was a factor if performance had declined.

6.3 Assessment T2

The purpose of this second assessment was to measure time on-task, against T1 which formed the baseline measure. This was to establish if the first intervention phase had effected a positive change. Tasks were designed to assess whether Bob had understood the concepts covered.

Dependent variable:

- Time on-task (first fifteen minutes of the session)

Independent variable:

- Number patterns (one to seven)
- Identifying and matching patterns that are the same
- Continuing an alternating ABAB pattern.

[57] Bob was in his wheelchair instead of his height adjustable specialist seating.

Situational variable:

- Interruptions (adult entering and leaving the room to use the computer behind Bob)

Participant variable: (in order observed)

- Yawning
- Bouncing up and down in chair
- Slouches in chair and rubs eyes (appears tired)
- Yawns
- Slumps down and rubs eye
- Plays with resources during Task 4
- Flicks wooden shape
- Plays with shapes (imagines boats).

Materials

The materials were chosen because Bob had previously encountered them either during the pre-intervention assessments or cycle one of the intervention sessions. This minimised the likelihood of attention to task being diverted by the introduction of novel objects. This was important as time on-task was being measured. Resources included: digit cards one to seven, unifix cubes in differing arrangements. Coloured wooden three-dimensional shapes and white two-dimensional shapes were used to replicate the previous work covered on pattern.

Procedure

The procedure described previously regarding the initial chat and setting up the camera was followed. Bob was introduced to the first task which involved thinking about numbers. Researcher put a number card (one) on the table and Bob was asked to name it. This was repeated with a second card (two). The card was then placed to the right side of the first card, to form a horizontal row, in front of Bob. Researcher then stated, “If this is a number pattern, what comes next?” Researcher placed a card to the right of number two and then pointed to the first card. Bob was asked to describe the number pattern. This was followed until all the cards had been placed in the row. Bob was then asked to describe the pattern. For example, by using the term ‘alternating’ in

the correct context. For the next task, researcher placed three strips of unifix on the table in front of Bob. Bob was asked to identify which ones were patterns and to explain why. Researcher then placed a yellow hexagon on the table and stated, “I’m going to have a yellow one, and then I’m going to have a red one” and placed a red parallelogram to the right of the yellow hexagon. Then pointed to the yellow and red in turn and said, “If it’s alternating, what one do I want to have next?” Then, pointed to the space to the red parallelogram. The same procedure was followed for the next yellow shape. Researcher then slid a range of different shapes on the table and Bob was asked to continue the alternating pattern with four more shapes.

For the next task, researcher stated, “I’m going to put three rows out Bob, and I want you to tell me which two rows are the same”. Researcher put a white paper circle on the table followed by the rest of the shapes needed for the task, in three horizontal rows on the table. Researcher stated, “So, two of them are the same, I want you to tell me which two are the same…. just pop them out. Do you remember doing these jobs?” Researcher waited then said, “I want you to tell me which two rows are the same (pointed to each row in turn), here’s a row, here’s a row, and here’s a row. Which two rows match? (waited) Which two rows match?”

For the next task, researcher placed three strips of unifix blocks on the table and said, “I want you to tell me which two match, which two go together?” The strips on either side of the middle strip were alternating blue and white cubes. The middle strip comprised blue and white cubes in a random order. For the next task, researcher said, “What I want you to do now Bob, is to make up your own pattern, using the shapes. Okay? I want your pattern to repeat. So how many different shapes are you going to use?” Researcher placed a variety of coloured three-dimensional shapes on the table. For the next task, Bob was asked to make his own pattern using the coloured, wooden shapes, and to explain why it was a pattern. Finally, Bob was asked to make a pattern using the unifix cubes which were placed in front of him on the table. On completion, he was asked to explain his pattern. Table 6.5 provides an overview of the order of tasks and a brief description of each.

Table 6.5 Details and time-line of T2

Timeframe	Tasks	Description
29/02/16	1	To make a number pattern using digit cards 1,2,3,4,5,6,7.
	2	To identify which strips of unifix cubes are a pattern when presented with 3 strips comprising 1) 3 black, 2 orange, 2 yellow, 3 orange cubes, 2) two black, one white, 3 pink, one green, 3 orange cubes, 3) alternating orange and yellow cubes.
	3	To continue a pattern started by the researcher using coloured wooden shapes presented in a horizontal row, left to right (yellow hexagon, red parallelogram, yellow hexagon, red parallelogram).
	4	To identify which two rows of white two-dimensional shapes 'match' when presented with 3 horizontal rows, one on top of the other (top and middle row = circle, triangle, triangle, square, circle. Bottom row = triangle, circle, triangle, triangle, square).
	5	To identify which two strips of unifix cubes 'go together' when presented with 3 strips comprising blue and white colours. Matching strips arranged in an alternating blue and white pattern.
	6	To construct a 'repeated' ABAB pattern using different coloured two-dimensional shapes chosen by Bob.
	7	To construct a pattern using different coloured unifix cubes chosen by Bob.

T2 Results

Tasks 1-5

Description of tasks (coded for actions and on-task and off-task behaviours during the first 15 minutes of the assessment)

Task 1 (Looking): To make a number pattern using digit cards one to seven (new task).

Task 2 (Looking): To identify which strips of unifix cubes are a pattern when presented with three strips comprising:

1) thee black, two orange, two yellow, three orange cubes
2) two black, one white, three pink, one green, three orange cubes
3) alternating orange and yellow cubes.

Task 3 (Handling): To continue an ABAB repeating pattern started by the researcher using coloured wooden shapes presented in a horizontal row. Left to right: yellow hexagon, red parallelogram, yellow hexagon, red parallelogram.

Task 4 (Looking): To identify which two rows of white two-dimensional shapes 'match' when presented with three horizontal rows, one on top of the other. Top and middle row: circle, triangle, triangle, square, circle. Bottom row: triangle, circle, triangle, triangle, square.

Task 5 (Looking): To identify which two strips of unifix cubes 'go together' when presented with three strips comprising blue and white colours. Matching strips arranged in an alternating blue and white pattern

Shown in on-task and off-task graphs: coded for behaviours only (entirety of assessment)

Task 6 (Handling): To construct a 'repeated' ABAB pattern using different coloured two-dimensional shapes chosen by Bob.

Task 7(Handling): To construct a pattern using differnet coloured unifix cubes chosen by Bob.

Table 6.6 is presented next to show looking and handling actions across Task 1 to Task 5. As this was the first fifteen minutes of the assessment tasks 6 and 7 are not included. This is followed by Figure 6.3, which shows the percentage of time Bob was on-task and off-task for the entirety of the session. Figure 6.4, provides a breakdown of all off-task behaviours.

Table 6.6 T2: Percentage of time actions were observed during the first 15 minutes of the assessment.

Action	*Tasks score*				
	1 Looking task[1] (%)[3]	**2 Looking task (%)**	**3 Handling task[2] (%)**	**4 Looking task (%)**	**5 Looking task (%)**
Looking Object	63 *(41/66)[4]*	**81** *(25/31)*	84 *(20/24)*	**89** *(8/9)*	**100** *(17/17)*
Researcher	43 *(28/66)*	36 *(11/31)*	50 *(12/24)*	78 *(7/9)*	24 *(4/17)*
Handling Pointing-at	*3 (2/66)*	26 *(8/31)*	0 *(0/24)*	12 *(1/9)*	18 *(3/17)*
Reaching-towards	0 *(0/66)*	0 *(0/17)*	5 *(1/24)*	0 *(0/9)*	0 *(0/17)*
Handling-both hands	0 *(0/66)*	**29** *(9/31)*	9 *(2/24)*	0 *(0/9)*	24 *(4/17)*
Handling-right hand	2 *(1/66)*	**7** *(2/31)*	0 *(0/24)*	0 *(0/9)*	0 *(0/17)*
Handling-left hand	25 *(16/66)*	26 *(8/31)*	42 *(10/7)*	23 *(2/9)*	42 *(7/17)*
Speaking Speaking	61 *(40/66)*	65 *(20/17)*	63 *(15/24)*	45 *(4/9)*	59 *(10/17)*
Vocalising	5 *(3/66)*	0 *(0/17)*	13 *(3/24)*	0 *(0/9)*	0 *(0/17)*

Notes:
Looking-task[1] Tasks dependent upon looking, as the predominant action, for successful completion.
Handling-task[2] Tasks dependent upon handling, as the predominant action, for successful completion.
%[3] Percentage of total time coded action was observed during task. Values round up to nearest whole value.
(41/66)[4] Range for each action coded. Number of times action was observed out of total number of events observed across the task. (Events refer to the series of actions observed within a ten second timeframe).

Figure 6.3 T2: The percentage of time Bob was attending to the task (measured by on-task behaviours)

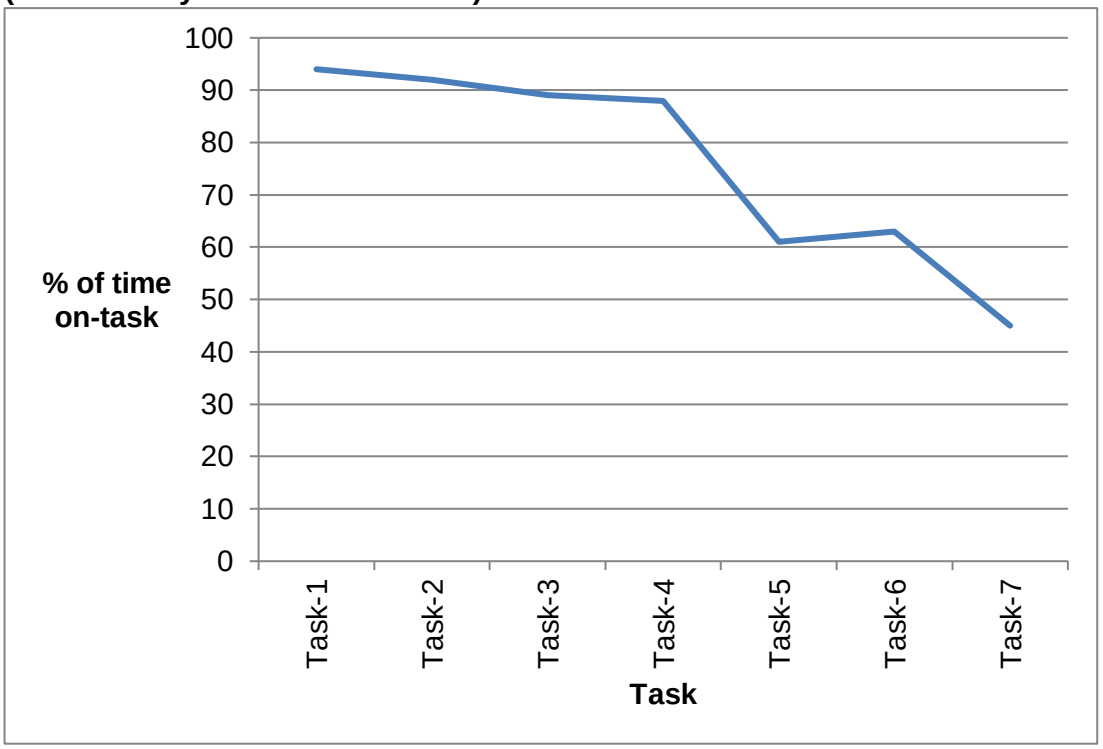


Figure 6.4 Off-task behaviours during T2

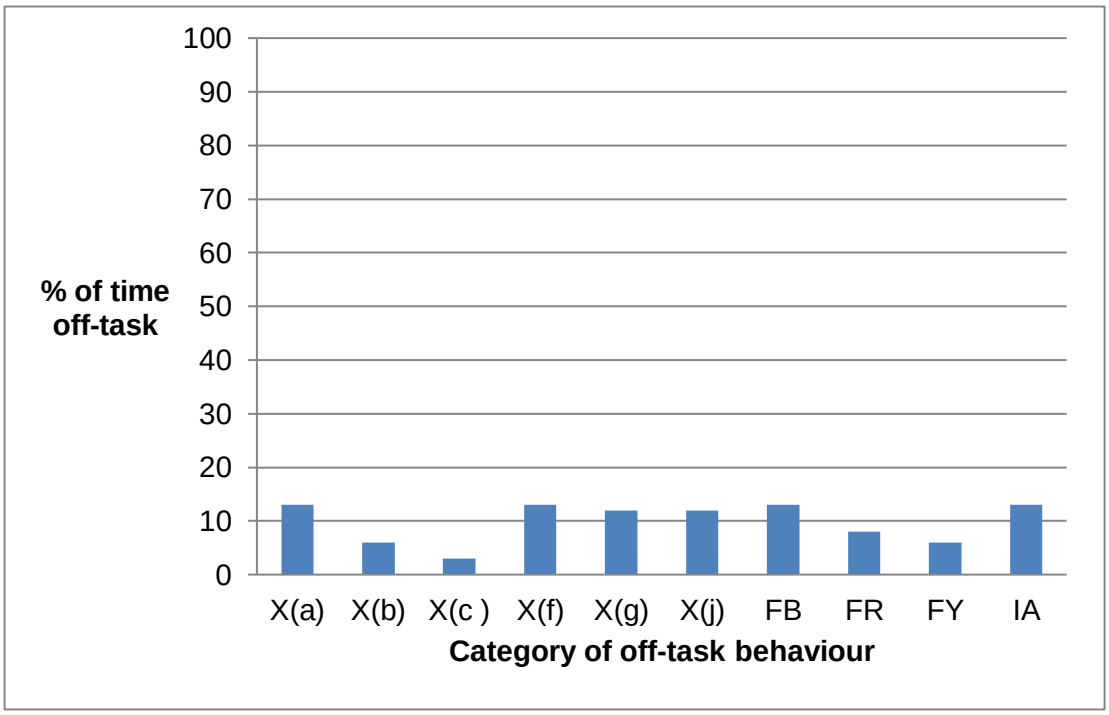


Table 6.7 Off-task behaviours observed in T2

Coded Behaviour	Off-task behaviours[1] Definition
X	**Off-task**
X(a)	Looking away from the equipment during a task, when visual attention required
X(b)	Looking away from the activity and/or not responding to a direct question
X(c)	Humming and/or playing with equipment during direct instruction
X(f)	Bouncing up and down in chair, flapping arms about, moving head from side to side repetitively
X(g)	Not responding to an instruction to carry out a task, and making sound effects
X(j)	Asking questions or making conversation unrelated to the task
F	**Behaviours which affect focus**
F(B)	Upper body posture slumped
F(R)	Rubbing eyes
F(Y)	Yawning
I	**Interruptions which affect focus**
I (A)	Adult entering space

Note: Behaviours[1] were observed at least once during T2.

Analysis

Results for T2 have been compared with the same tasks undertaken in T1. This was to determine if changes in behaviours occurred.

T2: Task 3 (Handling)

Task 7 in T1 involved the same instructions and resource but the pattern was changed from ABCABC to an ABAB pattern to simplify it. Comparative results show:

- Decrease in looking at-the-object from 97% to 84%
- Increase in speaking from 23% to 59%
- Increase in looking at the researcher from 23% to 50% (researcher prompts included: pointing at shapes and naming the colour)
- Increase in reaching-towards and use-of-both-hands
- Decrease in other handling-actions

- Talking is now purposeful and task-specific.

T2: Task 4 (Looking)

Presented as Task 1 in T1:

- Looking at the object has increased from 50% to 89%
- Looking at the researcher (when researcher is pointing at objects) has increased from 21% to 78%
- Pointing-at remains the same at 12%
- Decrease in other handling-actions
- Speaking has increased from 20% to 45%
- Vocalising decreased from 5% to 0%.

T2: Task 5 (Looking)

This was presented as Task 2 in T1. The following were evidenced:

- Increased looking at the object from 77% to 100%
- Increased looking at the researcher from 12% to 24%
- Decreased handling-actions overall
- 6% increase handling-both-hands
- 1% increase handling-left-hand
- Decrease in speaking by 6% but purposeful responses to researcher led questioning about the task (video evidence)
- Increased actions (looking) appropriate to task
- Handling-actions involved picking up the unifix strips to examine them at a different angle.

On-task and off-task behaviours

- 27% of recorded behaviours indicate that fatigue caused lowered engagement.
- 13% of off-task behaviours resulted from interruptions to the workspace.
- A gradual decline in engagement was evident from Task 1, cycle one to Task 5 cycle two regardless of the type of resource used.

Summary of differences between cycle one and cycle two

Results of all tasks demonstrate a positive impact of intervention 1

- An increase in the percentage of time looking
- A notable decrease in playing and fiddling with resources compared to T1
- An increase in speaking
- A decrease in vocalisation
- Time spent handling did not increase but the handling observed was purposeful and appropriate to the task (video evidence).

Interpretation of T2

Engagement, measured by time on-task, steadily declined between Task 1 and Task 8, see Figure 4.13 during this assessment. 40% of off-task behaviours resulted from a combination of fatigue and interruptions to the environment. However, when engaged, more time was spent looking and considering choice and placement of shapes prior to handling. An anomaly is evident in Task 5 because despite an increase in off-task behaviours, there was also an increase in appropriate actions to achieve the outcome (match unifix strips). This suggests that the demands of the task were not affected by interruptions or fatigue. This could be due to enjoyment of the task and/or low cognitive demand; thinking was not adversely affected by changes in attentional levels.

6.4 Assessment T3

This third assessment provided a point of reference for the post-intervention assessment and the delayed post-intervention assessment, described in the following chapter. Non-numerical patterns used before were revisited so that the dependent variable could be measured against T1.

Materials

The resources included: unifix cubes (in arrangements of tall and short green, and same length black and white strips, white sausages and balls (made from playdough), and white and blue balls (made from playdough).

Setting

The only available space was the hall. A grey dining table was set up which did not provide a high level of visual contrast for some of the resources used. The video camera was positioned on a gym 'horse' and due to the incorrect height, Bob's head was not always captured on the video footage. The hall echoed and staff periodically walked through creating distractions. Before the assessment had completed lunch-time staff entered with the food trolleys to set up. The assessment was ended early due to the noise and visual distractions.

Procedure

The order of tasks is presented in Table 6.8 which follows. The same procedure was followed for tasks presented earlier to provide consistency with language and placement of resources. The seven green unifix strips, used for Task 1, were placed on the table in front of Bob. He was asked by the researcher to make a pattern out of them. Bob had some difficulties with the placement of the strips as they fell over repeatedly. Researcher offered help and when accepted, positioned them in the same vertical placement. When Bob had completed the task, the researcher asked him what type of pattern he had made.

The same procedure was followed for Task 2, using black/white unifix strips, comprising six cubes in each strip. Task 3 started with researcher saying, "Now, I want you to make an alternating pattern that repeats, so it does the same thing over and over again, using two different shapes." A lump of white playdough was placed on the table in front of Bob, by the researcher and Bob was offered help. The aim was repeated by the researcher, as Bob manipulated the dough, "So we are doing an alternating pattern." Bob was provided with help to make the shapes needed for the pattern but left to make the pattern independently.

Task 4 commenced with Bob choosing to use the blue playdough. Researcher stated the aim, "So, we are going to do an alternating pattern with the two colours Bob!" Bob is encouraged to make an alternating pattern using the blue and white playdough. As staff entered to set up the hall for

lunch, the researcher started to make an alternating pattern and Bob was prompted with “What’s next?” to complete it. When the pattern had been completed, Bob was asked to explain his pattern. Task 5 was then introduced by the researcher, “Now I want to see if you can do the same thing that you have done there using these for me.” The blue and white cuisenaire rods were placed on the table in front of Bob. Researcher then moved the playdough pattern further up the table to create space beneath them for the new pattern and stated, “You’re going to make the same pattern underneath Bob.” Table 6.8, presented next, provides a description and the order of each task.

Table 6.8 Details and timeline of T3

Timeframe	Tasks	Description
18/04/16	1	Construct an alternating tall and short pattern using 6 strips of green unifix cubes (assembled beforehand by researcher).
	2	Construct an alternating pattern using 6 strips of unifix cubes, of the same length (3 x black, 3 x white).
	3	Make an alternating pattern out of white playdough using two different shapes (sausages/balls, decided by Bob).
	4	Make an alternating pattern using 3 white and 3 blue balls (made out of playdough by Bob).
	5	Using cuisenaire rods, copy the ABAB alternating pattern constructed in Task 4.

The results of T3 are now presented. As discussed previously, the sessions were re-planned to focus on non-numerical pattern. Figure 6.5, provides photographic illustration of these tasks. Numicon, as both resource and approach to teaching, was eliminated and other tactile resources were introduced. The malleability of playdough provided an opportunity to introduce a new variable.

T3 consists of a series of alternating ABAB patterns using different variables: length, colour, shape and texture. The cognitive demands were therefore comparable with T1 and T2.

Tasks 1-5

Description of tasks and predominant action (coded for actions and on-task and off-task behaviours first 15 minutes only)

Task 1 (Handling): To construct an alternating ABAB tall and short pattern using six strips of green unifix cubes (assembled beforehand by researcher).

Task 2 (Handling): To construct an alternating ABAB black/white pattern using six strips of unifix cubes, of the same length (3 x black, 3 x white).

Task 3 (Handling): To make an alternating ABAB pattern out of white playdough using two different shapes (sausages/balls, decided by Bob).

Task 4 (Handling): To make an alternating ABAB pattern using three white and three blue balls (made out of playdough by Bob).

Shown in on-task and off-task graphs: coded for behaviours only (entirety of assessment)

Task 5 (Handling): Using cuisenaire rods, copy the ABAB alternating pattern constructed in Task 4.

Figure 6.5 Non-numerical tasks undertaken during T3Tasks: To make alternating ABAB patterns

1

2

Notes:
[1] The strips comprise the same coloured cubes. Two strips are arranged in an alternating pattern of tall and short. The length of the last strip in the row has been shortened by Bob.
[2]The strips are the same length but in two different colours (black and white).

Table 6.9 is presented next to show looking and handling actions across Task 1 to Task 4.

Table 6.9 T3: Percentage of time actions were observed during the first 15 minutes of the assessment.

Action	*Tasks score*			
	1 Handling task[1] (%)[2]	**2 Handling task (%)**	**3 Handling task (%)**	**4 Handling task (%)**
Looking Object	77 *(29/38)[3]*	93 *(12/13)*	84 *(55/66)*	73 *(13/18)*
Researcher	29 *(11/38)*	31 *(4/13)*	34 *(22/66)*	34 *(6/18)*
Handling Pointing-at	8 *(3/38)*	0 *(0/13)*	0 *(0/66)*	0 *(0/18)*
Reaching-towards	0 *(0/38)*	0 *(0/13)*	0 *(0/66)*	0 *(0/18)*
Handling-both hands	24 *(9/38)*	0 *(0/13)*	29 *(19/66)*	0 *(0/18)*
Handling-right hand	0 *(0/38)*	0 *(0/13)*	0 *(0/66)*	6 *(1/18)*
Handling-left hand	37 *(14/38)*	62 *(8/13)*	52 *(34/66)*	56 *(10/18)*
Speaking Speaking	71 *(27/38)*	70 *(9/13)*	62 *(41/66)*	50 *(9/18)*
Vocalising	11 *(4/38)*	0 *(0/13)*	8 *(5/66)*	6 *(1/18)*

Notes:
Handling-task[1] Tasks dependent upon handling, as the predominant action, for successful completion.
%[2] Percentage of total time coded action was observed during task. Values round up to nearest whole value.
(29/38)[3] Range for each action coded. Number of times action was observed out of total number of events observed across the task. (Events refer to the series of actions observed within a ten second timeframe).

Figures 6.6 and 6.7 are presented next which show the percentage of time on-task and the type of off-task behaviour recorded.

Figure 6.6 T3: The percentage of time Bob was attending to the task (measured by on-task behaviours)

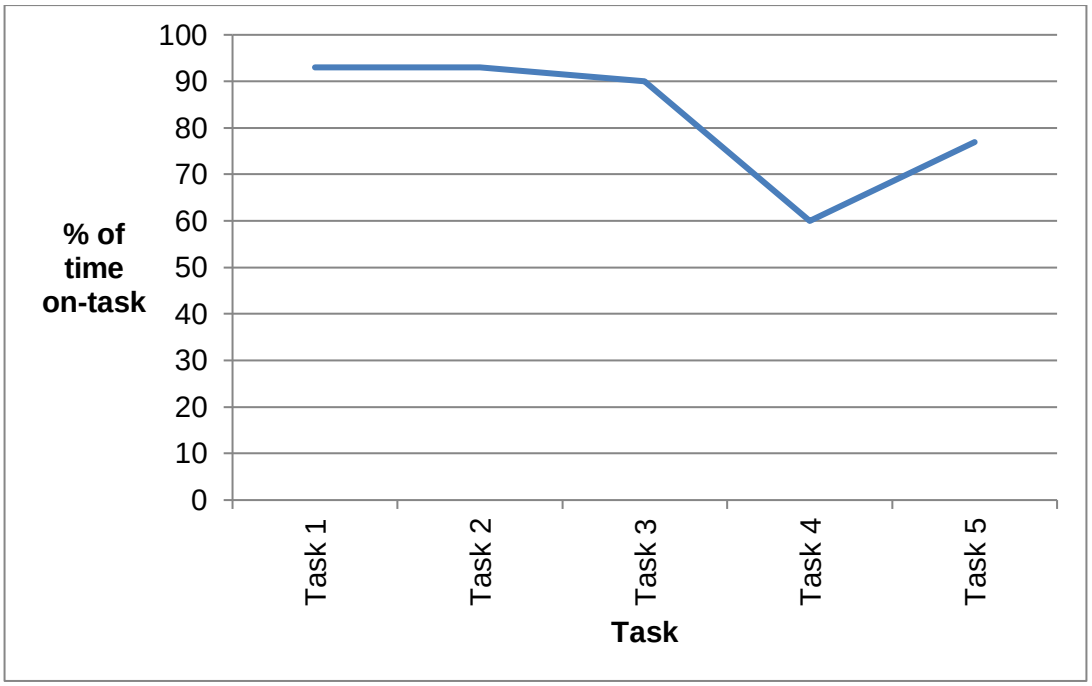


Figure 6.7 Off-task behaviours during T3

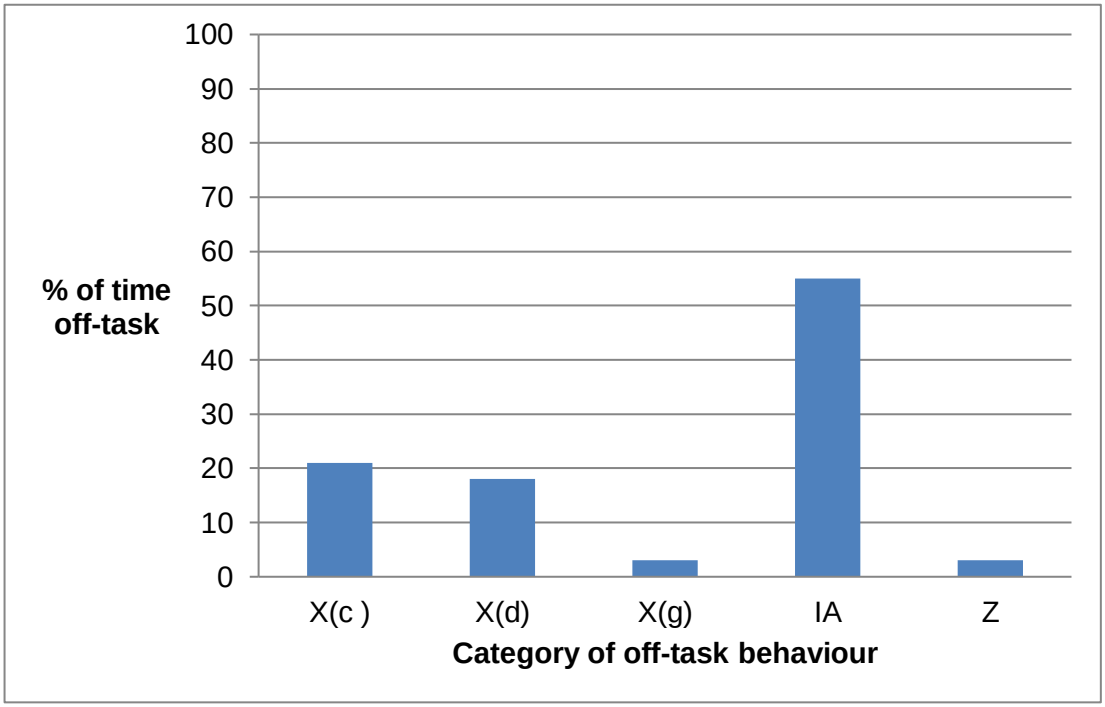


Table 6.10 Off-task behaviours observed in T3

Coded Behaviour	Off-task behaviours[1] Definition
X	**Off-task**
X(c)	Humming and/or playing with equipment during direct instruction
X(d)	Ignoring a question and fiddling with resources
X(g)	Not responding to an instruction to carry out a task, and making sound effects
I	**Interruptions which affect focus**
I(A)	Adult entering space
Z	Bob appears 'zoned out' for no apparent reason

Note: Behaviours[1] were observed at least once during T3.

Analysis

Across the assessment:

- time spent looking at-the-object ranges from 73% to 93%
- looking at the researcher ranges from 29% to 34%
- handling actions are predominantly undertaken with left hand
- speaking ranges from 50% to 71%.

Off-task behaviours significantly increased during Task 4 but declined slightly during Task 5.

Summary

T3 took place in the school hall which is also used as the dining room. A high level of Bob's off-task behaviours resulted from interruptions: noise, movement of adults and dining tables being positioned around him. Other off-task behaviours resulted from fiddling/playing with resources.

Interpretation of T3

Results of T3 provide evidence of a developing understanding of 'alternating' pattern using different variables: length, colour, shape and texture. Prior to the disturbances on-task behaviour remained high (over 90%). This is important because the fine-motor demands of the unifix tasks presented difficulty

(precision with placement). As help with physical placement was provided by the researcher, engagement was sustained. This suggests that associated motor difficulties did not reduce on-task attention. Repetition of ABAB patterns across all tasks may have been beneficial because Bob was able to increase on-task attention at the end of the assessment to just below 80%. This indicates that distractions do not disrupt the session indefinitely and Bob is learning to re-focus his attention to achieve the intended outcome.

6.5 Summary

This chapter provided an account of how the three assessments T1, T2 and T3 were conducted and the results for each. Chapter 7 reports the final assessments undertaken during this study which consisted of P1 (post-intervention assessment) and P2 (delayed post-intervention assessment).

Chapter 7: Post-intervention assessments

7.1 Introduction

This chapter provides an overview of the post-intervention assessments that were undertaken to establish if positive outcomes were sustained over time. The final delayed post-intervention assessment was carried out five weeks after the post-intervention assessment to establish if learning had been retained. As reported in Chapter 3, section 3.13, there were professional concerns about Bob's ability to retain information. These assessments provided analysis of the following:

- Percentage of time spent on-task for the entirety of the assessment
- A breakdown of all off-task behaviours using predetermined coded categories
- Trends and changes across the entirety of the intervention
- Analysis of all actions: handling, looking and speaking for the first fifteen minutes of each assessment.

The first fifteen minutes only were coded for actions because this was considered a reasonable time period for the display of Bob's optimum performance before it was affected by fatigue. However, all of the tasks were coded for on-task behaviours. This provided a measure of whether Bob was able to sustain attention beyond the optimum time period or whether factors not associated with motor impairment such as slight distractions and possible boredom decreased engagement. Thus, all assessment tasks were coded in their entirety to measure on-task behaviours but only the first fifteen minutes of the assessments were coded for actions.

7.2 Post-intervention assessment (P1)

This assessment took place three weeks after T3; it was the first day back to school after the half-term holiday. The first three tasks were a repetition of tasks carried out in T3. Cognitive demands increased for Task 5 which re-introduced Task 7 from T1 (ABCABC pattern using three different coloured shapes).

Materials

The first three tasks and resources were selected to replicate T3 and were presented in the same order to enable a comparison of the dependent variable (time on-task). The last two tasks involved the familiar coloured, wooden shapes and were aimed at assessing, firstly Bob's ability to independently construct an alternating ABAB and, secondly to continue an ABCABC pattern.

Procedure

As the tasks were repetitions of previous work undertaken with Bob, the same procedure was followed for each one, as described in section 6.2, page 136.

Tasks 1-3 (coded for actions and on-task and off-task behaviours)
Description of tasks and predominant action required

Task 1(Handling): To construct an alternating ABAB tall and short pattern using six strips of green unifix cubes (assembled beforehand by researcher).

Task 2 (Handling): To construct an alternating ABAB black/white pattern using six strips of unifix cubes, of the same length (3 x black, 3 x white).

Task 3 (Handling): To make an alternating ABAB pattern out of white playdough using two different shapes (sausages/balls made by Bob, researcher and TA as part of the task).

Tasks 4-5 (coded for behaviours only)

Task 4 (Handling): To construct an alternating ABAB pattern using a red shape and a yellow shape.

Task 5 (Handling): To continue an ABCABC pattern started by the researcher uisng three different coloured shapes.

Table 7.1 is presented next to show looking and handling actions for Tasks 1, 2 and 3. This is followed by Figure 4.18 which shows the percentage of time Bob was on-task and then Figure 4.19 which provides a breakdown of off-task behaviours.

Table 7.1 P1: Percentage of time actions were observed during the first 15 minutes of the assessment.

Action	Tasks score		
	Task 1 Handling-task[1] (%)[2]	**Task 2 Handling-task (%)**	**Task 3 Handling-task (%)**
Looking Object	71 *(22/31)[3]*	*95 (16/17)*	76 *(93/123)*
Researcher	*42 (13/31)*	*42 (7/17)*	35 *(42/123)*
Handling Pointing-at	*0 (0/31)*	*0 (0/17)*	2 *(2/123)*
Reaching-towards	*0 (0/31)*	*0 (0/17)*	*2 (2/123)*
Handling-both hands	*7 (2/31)*	*24 (4/17)*	13 *(15/123)*
Handling-right-hand	*0 (0/31)*	*12 (2/17)*	1 *(1/123)*
Handling-left hand	*39 (12/31)*	*30 (5/17)*	36 *(44/123)*
Speaking Speaking	*49* ***(15/31)***	*36 (6/17)*	*18 (22/123)*
Vocalising	*13 (4/31)*	*18 (3/17)*	*6 (7/123)*

Notes:
Handling-task[1] Tasks dependent upon handling, as the predominant action, for successful completion
%[2] Percentage of total time coded action was observed during task. Values round up to nearest whole value.
(22/31)[3] Range for each action coded. Number of times action was observed out of total number of events observed across the task. (Events refer to the series of actions observed within a ten second timeframe).

Figure 7.1: P1: The percentage of time Bob was attending to the task (measured by on-task behaviours) across the assessment.

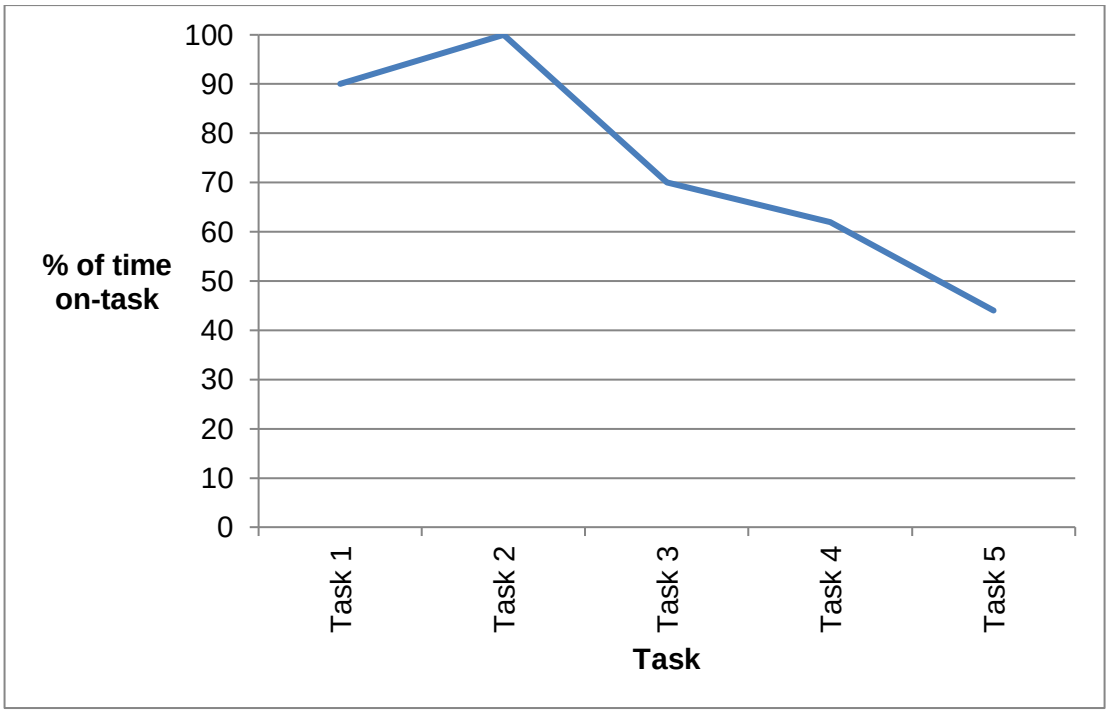


Figure 7.2: P1: Percentage of time off-task across the assessment.

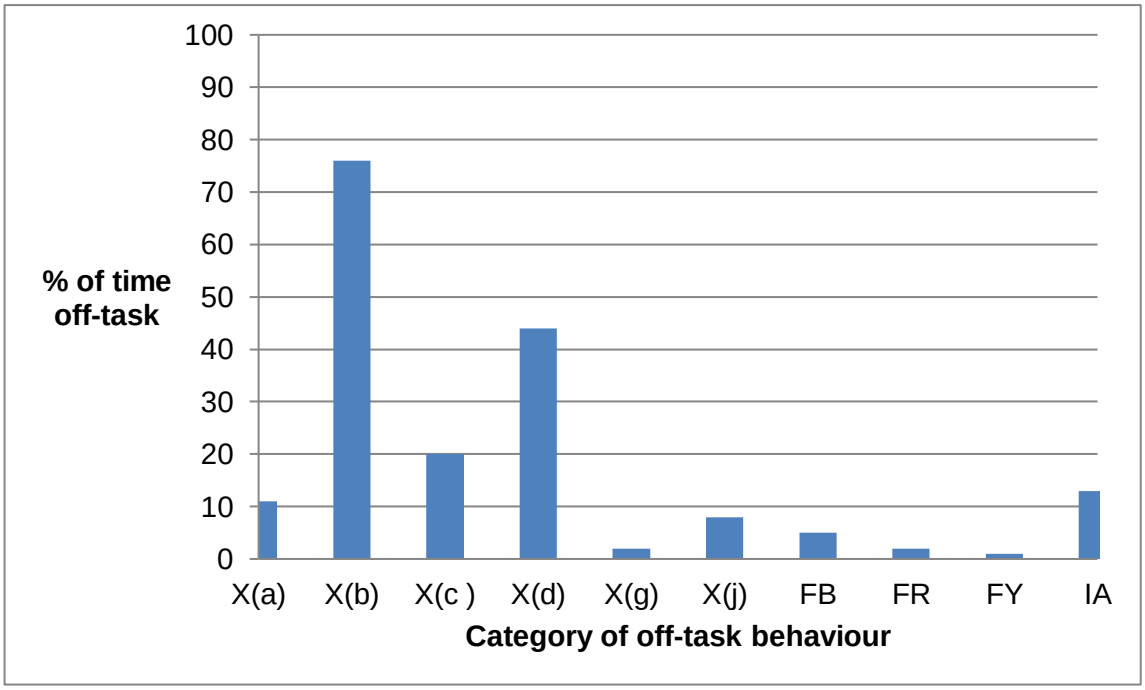


Table 7.2 Off-task behaviours observed in P1 assessment

Coded Behaviour	Off-task behaviours[1] Definition
X	**Off-task**
X(a)	Looking away from the equipment during a task, when visual attention required
X(b)	Looking away from the activity and/or not responding to a direct question
X(c)	Humming and/or playing with equipment during direct instruction
X(d)	Ignoring a question and fiddling with resources
X(g)	Not responding to an instruction to carry out a task, and making sound effects
X(j)	Asking questions or making conversation unrelated to the task
F	**Behaviours which affect focus**
F(B)	Upper body posture slumped
F(H	Head resting on table
I	**Interruptions which affect focus**
I(N)	Environmental noise
I(A)	Adult entering space

Notes:
Behaviours[1] were observed at least once during P1.

Analysis

Engagement in tasks declined across the entirety of the assessment. X(b) suggests lack of interest although X(c) and X(d) indicate engagement with the resources through exploration. Some off-task behaviours suggest tiredness.

A comparison with the results from T3 shows similarities in actions undertaken for the same tasks. The most noteworthy difference is the percentage of time speaking. This ranged from 18% to 49% in assessment 3 to 62% and 71% in this assessment. Whilst there was an overall increase in off-task behaviours across the assessment, on-task behaviours for the first two tasks were comparable to those demonstrated during T3. On-task behaviours increased to 100% during Task 2.

Summary

Vocalisation across the assessment showed a slight increase and included general sound effects, such as humming when playing/fiddling with the

playdough. Off-task behaviours declined during the final two tasks which involved constructing ABAB patterns using two-dimensional coloured shapes. A comparison with off-task behaviours for the same tasks presented in T1 and T2 show an increase from 30% to 40% and 40% to 56% respectively.

Interpretation of initial post-intervention assessment (P1)

The change in the pattern of these results, compared to T1,T2 and T3 indicates that when Bob is engaged, actions appropriate to the task increase. Based upon researcher/practitioner judgement, the results suggest that engagement is high when Bob demonstrates an understanding of the task, regardless of the resource or fine-motor demands required. Off-task behaviours seem to increase when the demands of the task increase or when Bob is asked to construct a pattern with two-dimensional coloured wooden shapes.

7.3 Delayed post-intervention assessment (P2)

The results are presented next for the delayed post-intervention assessment. This final assessment was designed to repeat some of the tasks presented at the start of the intervention. It was reasoned that if on-task behaviours increased, whilst time taken to complete the tasks decreased, Bob's understanding of the concepts had been learned and remembered (if he completed them successfully). This would show that the intervention had made a positive impact upon attention.

Tasks 1 and 2 were included because they were the same as the tasks used in T2, T3 and the post-intervention assessment. Task 3 was designed to provide a comparison to the same task undertaken during T1 and the post-intervention assessment. Task 5 was first introduced during the pre-intervention assessments of pattern awareness (activities 1). This provided scope to measure any change that had occurred. Task 6, initially presented during the pre-intervention assessments of pattern awareness (activities 2), was repeated to provide a measure of change in on-task behaviour. Finally, Task 7 was incorporated to enable a comparison between the same task undertaken during T2.

Materials

were repeated from previous assessments the same materials As these tasks were used for each task. (See section 6.2, page 136).

Procedure

The procedure and language used for each task were as similar as possible to those in the original presentation. A transcript of this assessment can be seen in appendix seven, page 266.

Tasks 1-6 (coded for actions and on-task and off-task behaviours)

Task 1(Handling): To construct an alternating ABAB tall and short pattern using six strips of green unifix cubes (assembled beforehand by researcher).

Task 2 (Handling): To construct an alternating ABAB black/white pattern using six strips of unifix cubes, of the same length (3 x black, 3 x white).

Task 3 (Looking): To identify which two strips of unifix cubes 'go together' when presented with three strips comprising pink and brown colours (matching strips arranged in an alternating ABAB pink and brown pattern).

Task 4 (Handling): To continue an ABAB pattern started by the researcher using coloured wooden shapes presented in a horizontal row, left to right (red parallelogram, yellow hexagon, red parallelogram, yellow hexagon).

Task 5 (Handling): To continue an ABCABC pattern started by the researcher using coloured wooden shapes presented in a horizontal row, left to right (red parallelogram, yellow hexagon, purple diamond, red parallelogram, yellow hexagon, purple diamond).

Task 6 (Handling): To make an alternating pattern using four white and four blue cuisenaire Rods. Copy the pattern using white balls and blue sausages (Figure 4.19).

Tasks 7-8 (coded for behaviours only)

Task 7 (Handling): To construct a pattern using any of the coloured wooden two-dimensional shapes.

Task 8 (Handling): To contiune an alternating ABCABC pattern started by the researcher uisng playdough (white ball, white sausage, blue ball).

Figure 7.3 Non-numerical tasks undertaken during the final assessment.
Task 6: To make an alternating ABAB pattern

[1]

Notes:
[1] To make an alternating pattern using 4 white and 4 blue cuisenaire Rods. Then, copy the pattern using sausages and balls made by Bob using playdough.

Table 7.3 is presented next to show looking and handling actions across the tasks. This is followed by Figure 7.3 which shows the percentage of time Bob was on-task and Figure 7.4 which provides a breakdown of off-task behaviours.

Table 7.3 P2:Percentage of time actions were observed during the first 15 minutes of the assessment.

Action	*Tasks score*					
	1 Handling-task[2] (%)[3]	**2 Handling-task (%)**	**3 Looking-task[1] (%)**	**4 Handling-task (%)**	**5 Handling-task (%)**	**6 Handling-task (%)**
Looking Object	70 *(27/39)[4]*	86 *(24/28)*	72 *(15/21)*	72 *(10/14)*	70 *(18/26)*	59 *(28/48)*
Researcher	52 *(20/39)*	36 *(10/28)*	**19** *(4/21)*	58 *(8/14)*	47 *(12/26)*	44 *(21/48)*
Handling Pointing-at	0 *(0/39)*	0 *(0/28)*	**5** *(1/21)*	0 *(0/14)*	0 *(0/26)*	2 *(1/48)*
Reaching-towards	0 *(0/39)*	0 *(0/28)*	0 *(0/21)*	15 *(2/14)*	0 *(0/26)*	0 *(0/48)*
Handling-both hands	*3* *(1/39)*	8 *(2/28)*	15 *(3/21)*	0 *(0/14)*	0 *(0/26)*	0 *(0/48)*
Handling-right hand	6 *(2/39)*	4 *(1/28)*	5 *(1/21)*	0 *(0/14)*	0 *(0/26)*	0 *(0/48)*
Handling-left hand	39 *(15/39)*	43 *(12/28)*	**38** *(8/21)*	43 *(6/14)*	43 *(11/26)*	42 *(20/48)*
Speaking Speaking	49 *(19/39)*	36 *(10/28)*	**48** *(10/21)*	15 *(2/14)*	39 *(10/26)*	52 *(25/48)*
Vocalising	6 *(2/39)*	0 *(0/28)*	5 *(1/21)*	15 *(2/14)*	0 *(0/26)*	0 *(0/48)*

Notes:
Looking-task[1] Tasks dependent upon looking, as the predominant action, for successful completion
Handling-task[2] Tasks dependent upon handling, as the predominant action, for successful completion
%[3] Percentage of total time coded action was observed during task. Values round up to nearest whole value.
(27/39)[4] Range for each action coded. Number of times action was observed out of total number of events observed across the task. (Events refer to the series of actions observed within a ten second timeframe).

Figure 7.4 P2: The percentage of time Bob was attending to the task (measured by on-task behaviours) across the assessment.

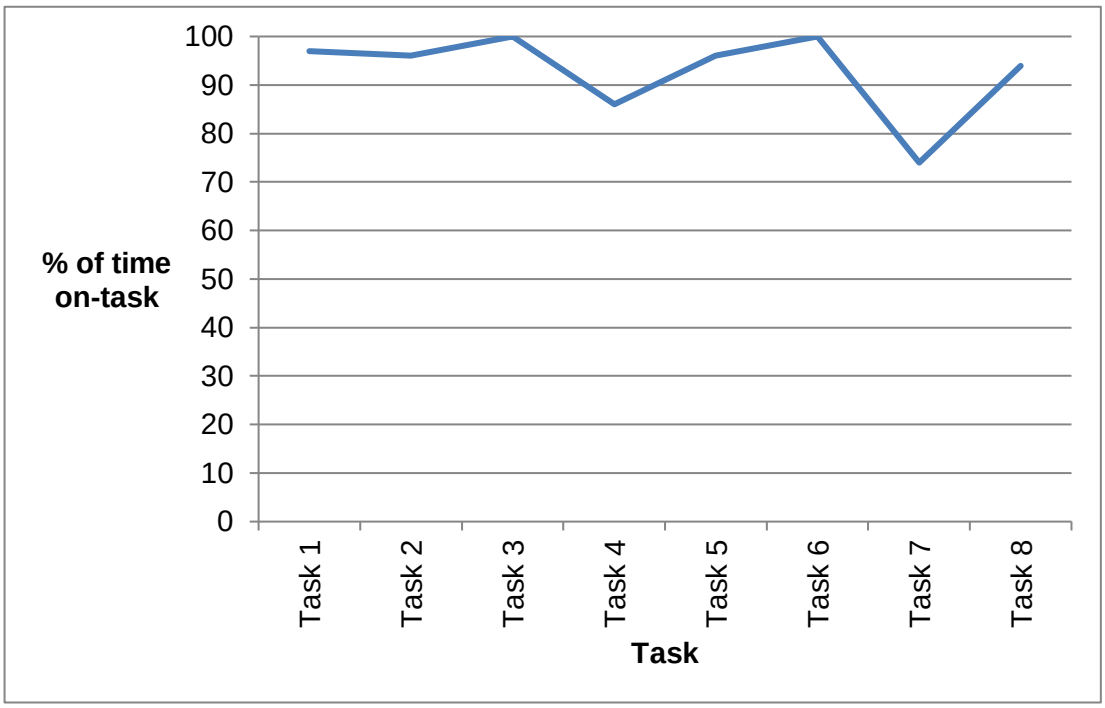


Figure 7.5 P2: Off-task behaviours observed across the assessment

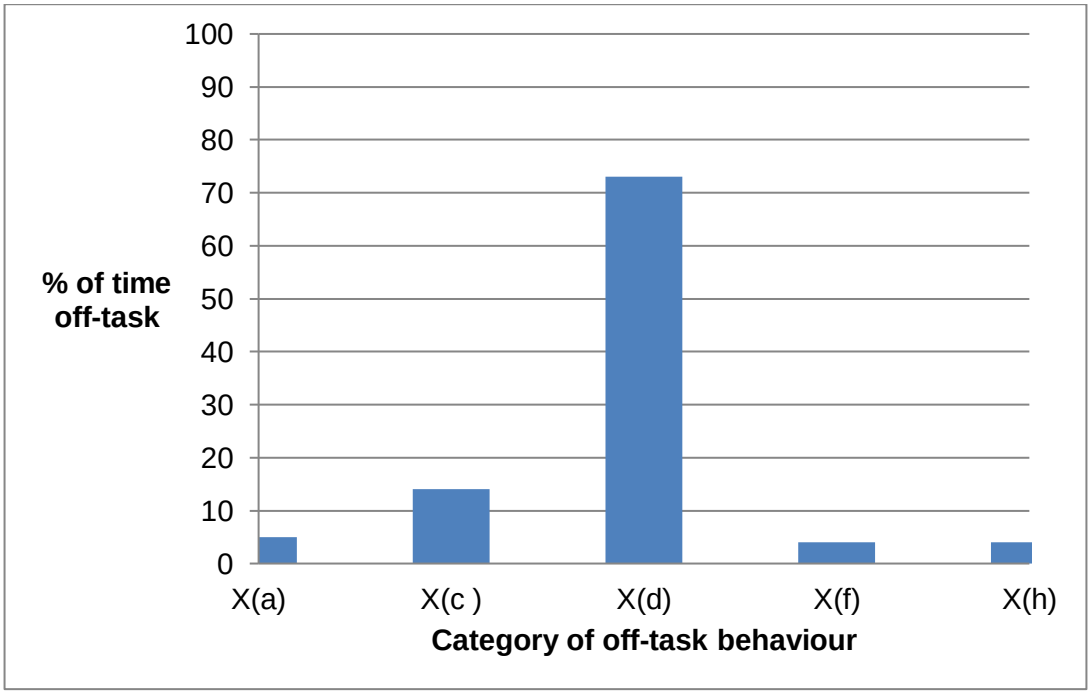


Table 7.4 P2: Off-task behaviours observed across the assessment

Coded Behaviour	Off-task behaviours[1] Definition
X	**Off-task**
X(a)	Looking away from the equipment during a task, when visual attention required
X(c)	Humming and/or playing with equipment during direct instruction
X(d)	Ignoring a question and fiddling with resources
X(f)	Bouncing up and down in chair, flapping arms about, moving head from side to side repetitively
X(h)	Saying 'done' or 'I'm not doing that' before the session has completed

Note: Behaviours[1] were observed at least once during P2.

Analysis

Six tasks were completed within the fifteen minute coded period. These consisted of five handling tasks and one looking task. What is noteworthy about the results is that the percentage of time spent looking at the researcher during handling tasks is comparable to the percentage of time speaking (with the exception of Task 4). This is irrespective of the type of handling-actions shown. This suggests a change in the pattern of actions has occurred since the start of the intervention.

Task 4 shows a different pattern to the other handling tasks and has been considered with reference to the notes made following observations of the video footage. Unlike the other handling tasks undertaken during this assessment, looking at the researcher totals 58% but speaking is only 15%. Task 4 involved the coloured wooden shapes which generally proved problematic across the Intervention. This appeared to be the result of Bob using the shapes for imaginative play. For example, shapes were re-positioned and orientated to represent peacocks and houses. Researcher notes state, '*Bob demonstrated confidence and attention was focused on the task*. He remained on-task for 86% of the time taken to complete the task. This was without prompts and took 1.09 minutes to complete. This suggests Bob constructed the pattern and provided verbal feedback quickly. As the initial ABAB pattern was constructed by the researcher whilst Bob was watching, this accounts for the percentage of time spent looking.

Task 3 involved looking at unifix cubes. Results show a different pattern of actions to the other tasks. Bob remained on-task for 100% of the time without prompts. Researcher notes state, *Bob demonstrated understanding of the task by selecting the matching strips without help, but struggled to articulate his thinking when asked to explain why the patterns match.* This could account for the low percentage of time spent looking at the researcher (19%) compared to time speaking (48%) because visual attention was focused on the unifix cubes. Consistent with previous interpretations of similar tasks, handling-actions involved a combination of pointing-at, both hands and right hand. This suggests visual attention was focused on hand function.

Engagement across the assessment remained consistently high ranging between 74% and 100%. Off-task behaviours peaked during Task 7 (to construct a pattern using coloured wooden two-dimensional shapes) but resumed to 94% for the final task. A total of 86% off-task behaviours related to playing and fiddling with resources but there was a decrease in the types of other off-task behaviours.

Summary

Results demonstrate that a change in the pattern of actions has occurred. When Bob's visual attention is focused on hand function and resources the percentage of time looking at the researcher when speaking decreases. Attention is also focused on the pattern when describing it to the researcher. When left hand use is high the time spent looking at the researcher increases during speaking.

Interpretation of delayed post-intervention assessment

100% engagement, measured through on-task behaviour, was achieved for Task 3 and Task 6. Both tasks involved an alternating ABAB pattern using two colours (pink and brown and blue and white respectively). Task 3 involved looking whereas Task 6 involved handling. Task 3 was introduced at the beginning of the intervention and repeated periodically to check consistency and was therefore a familiar task. Task 6 was introduced during P2 and involved greater cognitive demands, for example:

- remember the term ‘alternating’
- select correct resource independently and in the right order (white or blue)
- position correctly within a horizontal row
- copy the pattern with a different resource (characteristics changed: texture, shape and shades of colour).

7.4 Summary

This chapter has provided an account of the post-intervention assessments. Results suggest that the nature of the task and cognitive difficulties did not affect attention. As on-task behaviour increased to 94% at the end of the delayed post-intervention assessment the length of the session did not affect attention. This indicates that possible fatigue arising from CP was not a factor in the attentional difficulties recorded. Chapter 8 provides a comparison of the results of the post-intervention assessments.

Chapter 8: Comparison of the results of post-intervention assessments

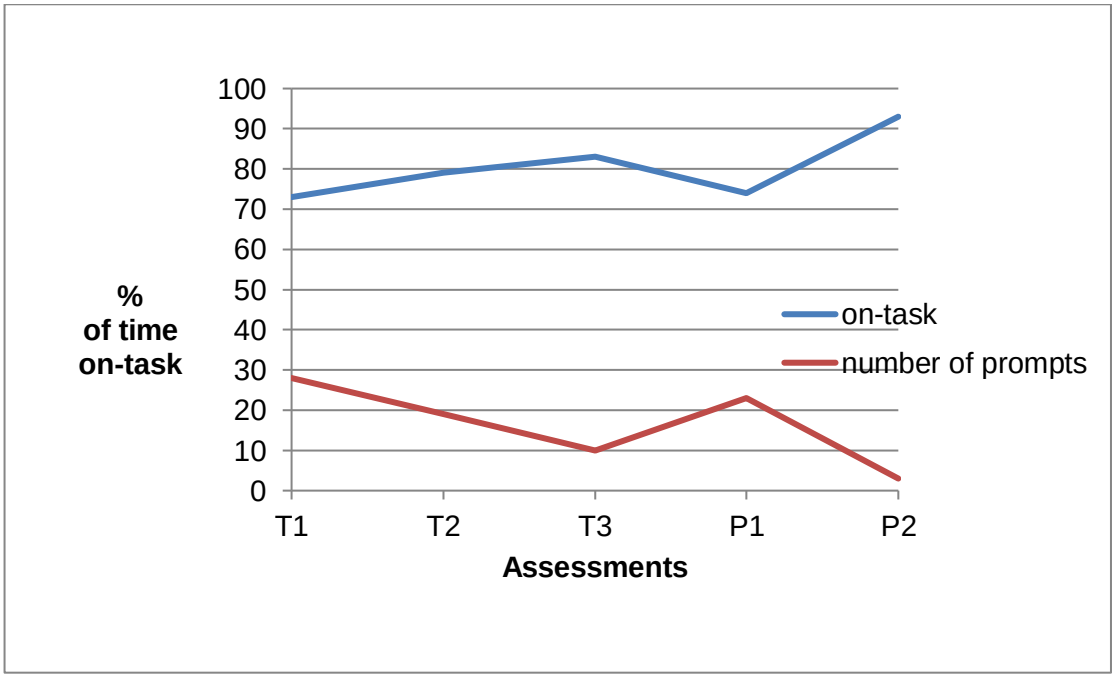
8.1 Introduction

To determine if performance improved as a result of the intervention, comparison of the results of all post-intervention assessments follows. This includes visual inspection of the graphed data for any patterns of changes in time on-task; any changes in time taken to complete tasks between T1, T2 and T3, and any relevant sets of actions and sequences of events. The initial post-intervention assessment is referred to and labelled 'P1'; and the delayed post-intervention assessment is referred to and labelled 'P2' throughout.

8.2 Increased periods of sustained attention

The first comparison is to determine if increased periods of on-task behaviours were evident across the intervention. Figure 8.1 shows the amount of time spent on-task for each assessment and the number of prompts provided to redirect attention when off-task.

Figure 8.1 Percentage of total time Bob was on-task during each assessment and the number of researcher prompts provided



Analysis

Figure 8.1 shows overall on-task behaviour between T1 and P2 improved. Mean on-task behaviours across T1 was 72% compared to 93% across P2. The number of prompts steadily decreased as time on-task increased. The P1 results disrupted this pattern, probably due (as already suggested) to tiredness on the day, and to the long holiday break prior to P1.

8.3 Comparison of the same tasks undertaken in T1 and repeated in P2

Table 8.1 sets out the tasks that were compared and the order of presentation for T1 and P2. Identical tasks are typed in the same colour. (Details of the tasks can be seen on pages 140 and 170.)

Table 8.1 The tasks that were compared and the task order for T1 and P2

Task	T1	P2
1	-	-
2	Match unifix blue and white	-
3	-	Match unifix pink/brown
4	Continue ABAB Numicon	Continue ABAB shape
5	-	-
6	-	-
7	Continue ABCABC	-
8	-	Continue ABCABC-

Figure 8.2 provides a comparison between the percentage of time spent on each of these tasks for T1 and P2.

Figure 8.2 Time taken to complete the same tasks in T1 and P2

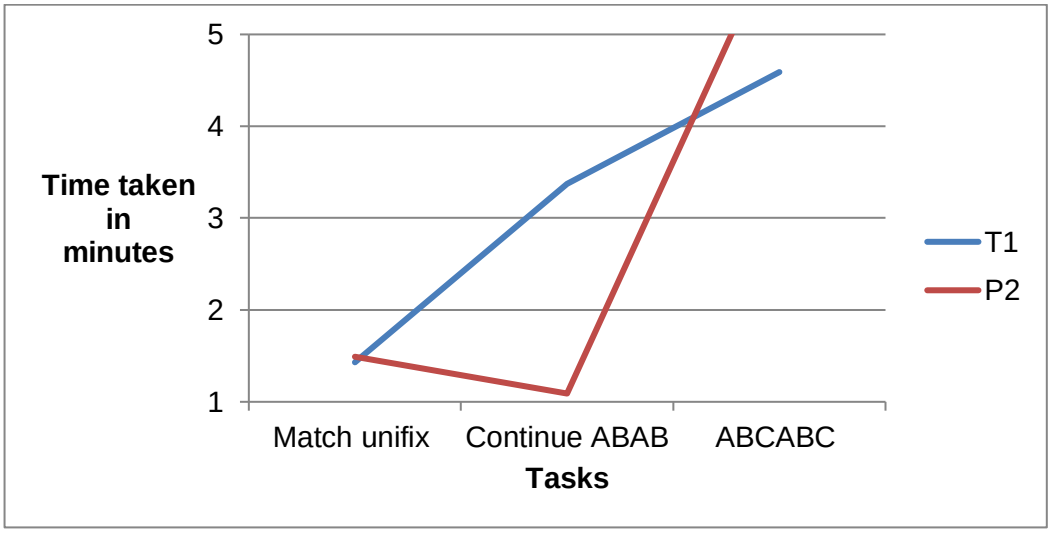
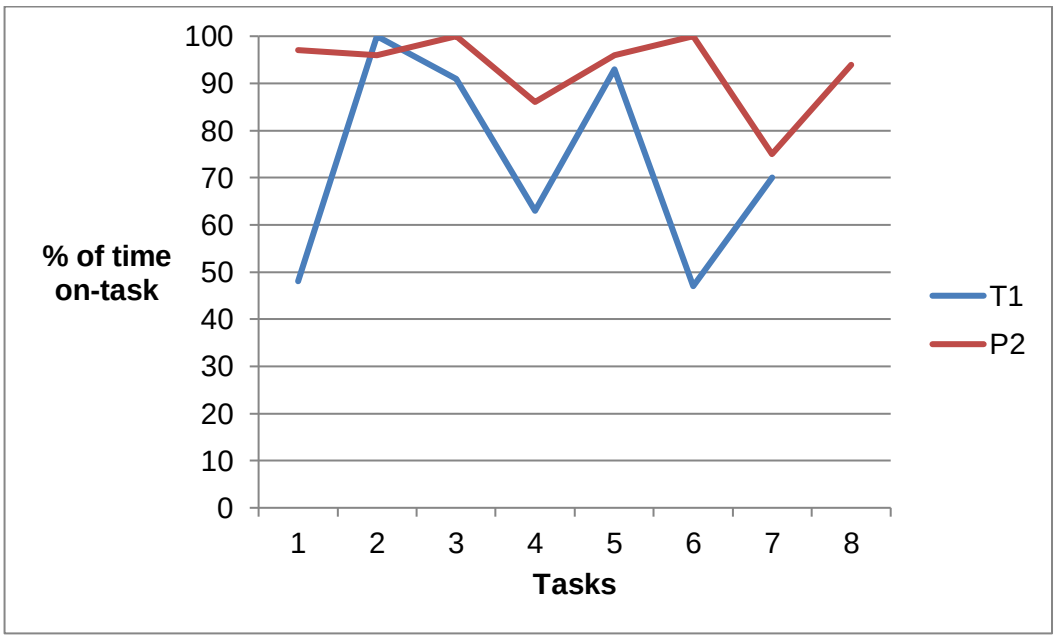


Figure 8.3 shows the percentage of time spent on each task in the order they were presented in the assessment. The purpose was to see if there was evidence of fatigue affecting attention over time.

Figure 8.3 Comparison of time on-task for T1 and P2



Analysis and interpretation

Figure 8.3 shows a pattern of varying attention levels across each assessment. That the sharp dip (at Task 6 for T1 and Task 7 for P2) is followed by an increase in time on-task at the end of each assessment suggests that it was not fatigue that was affecting attention. In T1 attention was lowest for the tasks involving number concepts (including Task 6). In P2 attention was lowest for a task that required Bob to construct his own pattern without a rule being provided (Task 7). This indicates that the cognitive demands were too challenging because when the same resource was used (coloured wooden shapes) but a rule was provided for Task 4, P2, time on-task was 96%. Time on-task for the same task (Task 7) presented in T1 was 70%. Therefore, time on-task may be influenced by degree of understanding of the pattern concept, familiarity with the resource, and expectations of the sessions, facilitated through practice. For Task 4, P2, increased time on-task coupled with a decrease in actual time to complete the task (by comparison with Task 7, T1) was evidenced on the video recording. Task 4, T1 involved constructing an ABAB pattern using Numicon shapes and constructing an ABAB pattern with wooden shapes in Task 4, P2. The tasks involved the same pattern rule and were also comparable in that coloured shapes were used (albeit Numicon shapes in T1 and coloured wooden shapes in P2). Bob took 3.37 minutes to complete this task in T1 and 1.09 minutes during P2[58]. This indicates that despite the change in resource, the pattern rule had been generalised and Bob was confident in making the pattern. Other factors to be considered are situational variables. This was recorded in researcher notes as, *a piano playing in a neighbouring room that was causing a distraction*. Other off-task behaviours for this specific task were recorded as playing with resources and making unrelated conversation.

Time on-task was 100% for the task involving matching the blue and white unifix strips (Task 2, T1), but decreased slightly to 93% when it was repeated in T1 (Task 5) using differently coloured strips (pink and purple). However time taken to complete the task decreased during T1 from 1.43 minutes to 1.13 minutes when presented the second time. Pink and purple may have been more difficult

[58] Length of time was calculated from exact timeframes of the video recordings of sessions.

to distinguish than blue and white. It is also possible that the repetition of the same task decreased attention due to boredom. Researcher notes confirm, *Bob was able to do the task without any prompts.* The same task in P2 (Task 3) using pink and brown unifix strips took 1.49 minutes and time on-task was 100%. I would conclude that the colour change was the main factor in reduced time on-task.

Overall, across the intervention, there was an increase in on-task behaviours, a decrease in off-task behaviours and a reduction in the number of prompts provided by the researcher. Engagement measured through on-task behaviour improved by over 20%.

8.4 Comparison between reference points T1 and T2

Because the intervention sessions were modified to remove number patterns, the three planned reference points T1, T2 and T3 could only be used for the tasks that were repeated. Table 8.2 provides an overview of the tasks compared (colour-coded to correspond with the same tasks compared in Table 8.1). Full details of the tasks can be seen in Chapter 6, on pages 140 and 149. Figure 8.3 shows a comparison for time on-task for the same tasks undertaken in T1 and T2, and the number of prompts required. This was to ascertain if the intervention had resulted in any improvement at this point of reference. This is followed by Figure 8.4 which provides a comparison of the amount of time it took to complete each task.

Table 8.2 Task order for T1 and T2 for comparison

Task	T1	T2
1	Match 2D shapes	Match number rows
2	Match blue and white	-
3	-	Continue ABAB shape
4	Continue ABAB Numicon	Match 2D shapes
5	-	Match blue and white
6	Match number rows	-
7	-	-

Figure 8.4 Comparison of time on-task for assessment tasks in T1 and T2 and the number of prompts for each task.

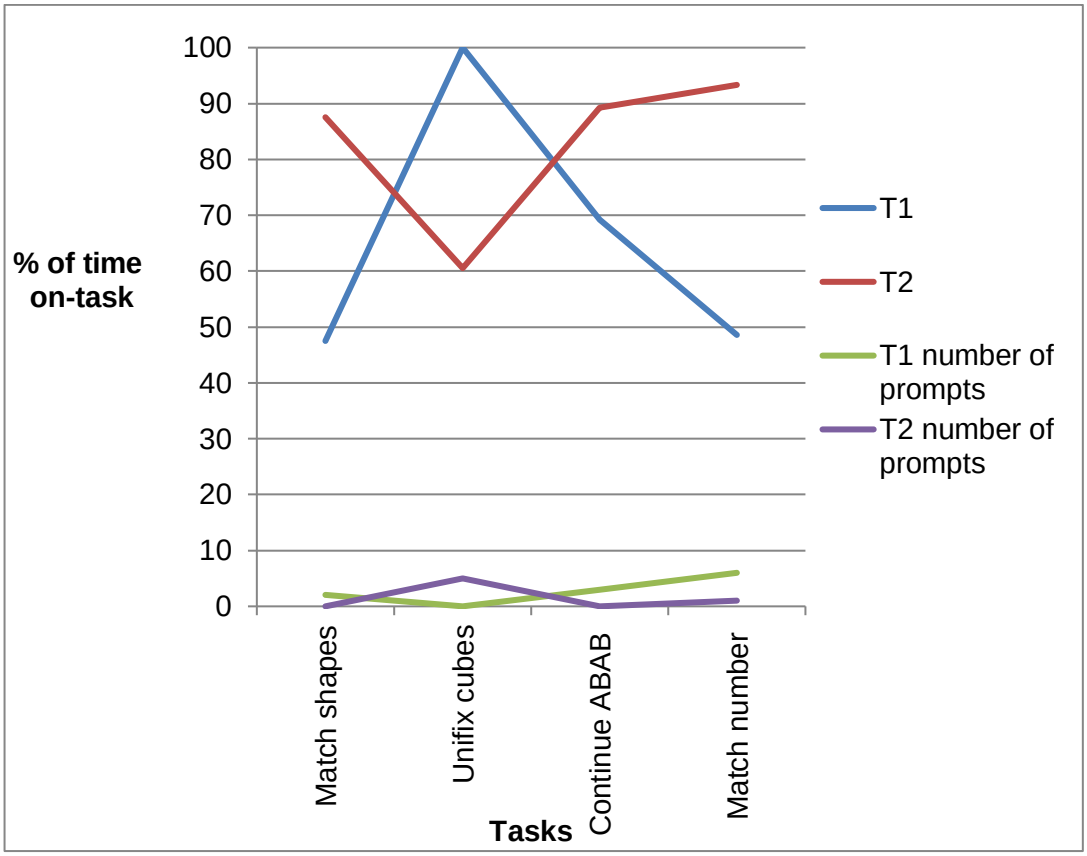
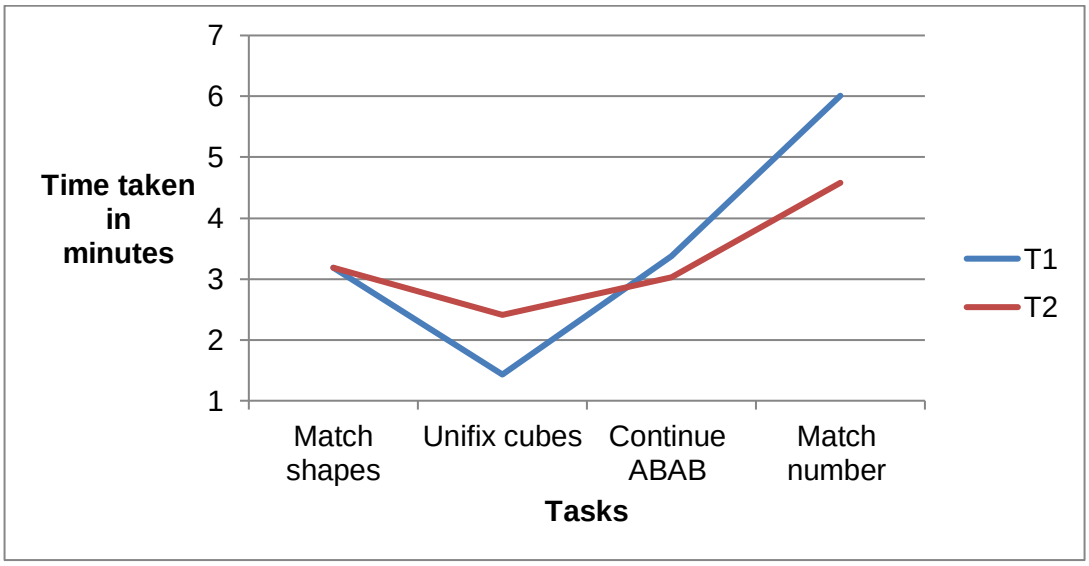


Figure 8.5 Time taken to complete the same tasks in T1 and T2



Analysis and interpretation

With the exception of the task involving matching strips of blue and white unifix cubes, an overall improvement can be seen in terms of increased time on-task and decreased numbers of prompts provided. Time taken to complete the matching shapes task remained the same but a reduction in prompts from two to nought was recorded. More time was needed to match the unifix strips and prompts increased from nought to five. Researcher notes made at the time of watching the video recordings state: *When asked a question, Bob attempts to answer but has difficulty articulating his reasoning. With continued questioning and probing, he demonstrates understanding. My impression is that when Bob has provided an answer of some sort, he does not feel the need to improve it, and therefore does not always demonstrate his full understanding.*

The off-task behaviours (7.14%) for this task were recorded as playing with resources. This reduced across the intervention when using unifix cubes to construct ABAB patterns (long and short and black and white). Finally, less time and a reduction in prompts was recorded for the other two tasks. When considering all these factors, an overall improvement can be claimed from the data presented.

8.5 Comparison between reference points T2 and T3

Due to the changes to tasks during the intervention sessions to omit number tasks, there is limited scope for comparison between T2 and T3 assessments. The two tasks selected use the same pattern rule although variables were different for T3. The comparison provides a measure of whether Bob was developing a secure understanding of the ABAB pattern rule and learning to generalise using different variables. Tasks compared and the order of presentation are shown in Table 8.3.

Table 8.3 Task order for T2 and T3

Task	T2	T3
1	-	Construct ABAB tall and short
2	-	-
3	Continue ABAB shape	-
4	-	-
5	-	Copy ABAB
6	Construct ABAB shapes	-
7	-	-

Figure 8.6 Comparison of time on-task for assessment tasks in T2 and T3 including number of prompts for each task.

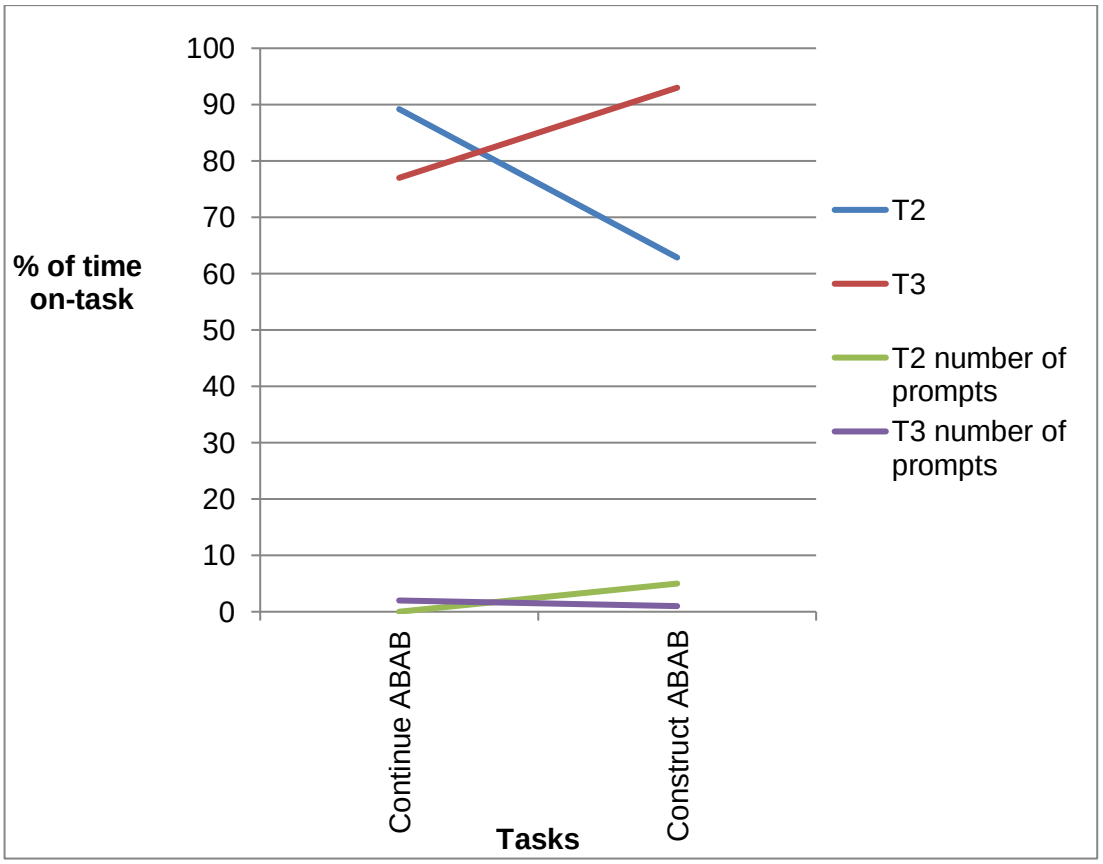
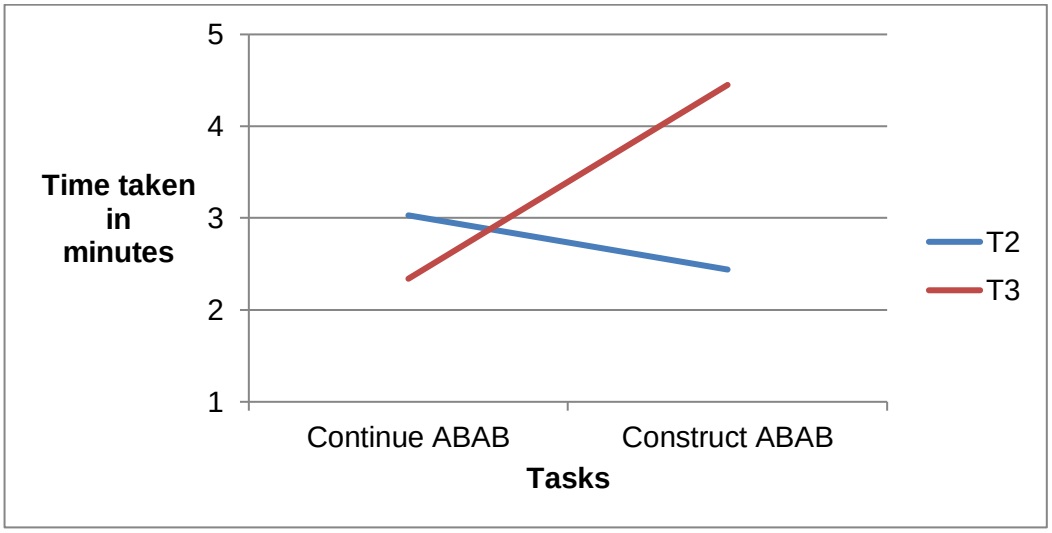


Figure 8.7 Time taken to complete the same tasks in T2 and T3



Analysis and interpretation

As this comparison is limited in scope due to the increased variables used in T3 and changes in types of tasks, researcher notes are included to provide a richer interpretation. These impressions were informed by my extensive experience as a teacher practitioner.

T2 Task 3

Bob was off-task for 10.8% of the total time taken to compete the task. This was recorded as: *looking away when visual attention required, or not responding to a question.* Notes state: *understanding of the concept is evident when listening orally to the pattern, 'yellow, red, yellow, red', but not secure visually. Pattern is repeated correctly once, then two random colours are added to the end of the pattern.*

T3 Task 5

This task was compared to T2, Task 3. Researcher notes state: *Bob works independently and spontaneously and corrects a mistake with prompting.*

T2 Task 6

Bob was off-task for 37% of the total time taken to complete the task, due to: ignoring questions and fiddling with resources. Understanding of an alternating ABAB pattern is evident as Bob states he is going to make a pattern using 'red,

white, red, white'. Five prompts were provided to redirect his attention to the task.

T3 Task 1

This task was compared to T2 Task 6. Researcher notes state: *Bob can recognise the difference between tall and short, when presented in strips the same colour, and can position the strips in an alternating pattern. Bob experiences difficulties with the fine motor demands of the task and requires help with the placement of them. He knows where they go within the row and demonstrates this through both action and verbal comments.*

Researcher notes following T2 state: *Bob appears to be able to recognise an alternating and repeated pattern when it is presented verbally. He can state what comes next when provided with a high level of scaffolding. Bob can select the right shapes in order to continue a pattern which is supported by the researcher with lots of verbal prompts. When left unsupported Bob's performance is inconsistent and he becomes easily distracted. Fatigue does not appear to impact on Bob's ability to remain engaged and there was no evidence of increased fatigue as the assessment progressed. Lower levels of engagement appeared to reflect poor motivation and interest due to a lack of understanding.*

Researcher notes following T3 state: *due to lack of availability of space this week, T3 assessment took place in the school hall which is also the dining room. Despite the environmental noise and interruptions during the assessment, Bob manages to sustain focus for a total of 82.6% of the total time. He is learning to re-focus with minimal prompts, during activities that use hard textured resources. The malleability of the playdough appears to cause high levels of off-task behaviours due to manipulating the resource and losing concentration for the actual task objectives. Bob is now working with increased confidence and this is reflected in his efforts to describe the patterns created.*

T3 provides evidence of an understanding of 'alternating' pattern using different variables:

- tall and short

- same colour/two shapes
- same shape/two colours
- copying an alternating pattern with a different resource.

In summary, the graphical data presented shows variable improvement in the tasks that were considered comparable. However, the additional notes provide evidence of an overall improvement and noticeably in Bob's ability to redirect his attention and describe patterns verbally with increasing confidence. The type of resources used seem to affect attention, for example, incidences of fiddling with resources was higher when the coloured wooden shapes were used for tasks. The factors which supported the success of the intervention, including resources, is expanded upon in Chapter 9, section 9.5.

8.6 Actions

The next set of results concern:

- changes in types of actions across the intervention
- changes in sequences of actions
- increased motor actions on the affected side of Bob's body.

The purpose was to consider whether these types of changes in actions were associated with increased attention.

Table 8.4 Comparison of actions during performance of identical tasks undertaken in T3, P1 and P2. Percentage of time actions were observed during the first 15 minutes of each assessment.

Action	*Tasks score*					
	A3 Task 1[1] (%)[3]	**P1 Task 1 (%)**	**P2 Task 1 (%)**	**A3 Task 2[2] (%)**	**P1 Task 2 (%)**	**P2 Task 2 (%)**
Looking Object	77 *(29/38)[4]*	71 *(22/31)[5]*	70 *(27/39)[5]*	93 *(12/13)*	*95 (16/17)*	86 *(24/28)*
Researcher	**29** *(11/38)*	**42** *(13/31)*	**52** *(20/39)*	**31** *(4/13)*	**42** *(7/17)*	**36** *(10/28)*
Handling Pointing-at	8 *(3/38)*	0 *(0/31)*	0 *(0/39)*	0 *(0/13)*	0 *(0/17)*	0 *(0/28)*
Reaching-towards	0 *(0/38)*	0 *(0/31)*	0 *(0/39)*	0 *(0/13)*	0 *(0/17)*	0 *(0/28)*
Handling-both hands	24 *(9/38)*	7 *(2/31)*	3 *(1/39)*	0 *(0/13)*	24 *(4/17)*	8 *(2/28)*
Handling-right hand	0 *(0/38)*	0 *(0/31)*	6 *(2/39)*	0 *(0/13)*	12 *(2/17)*	4 *(1/28)*
Handling-left hand	37 *(14/38)*	39 *(12/31)*	39 *(15/39)*	62 *(8/13)*	30 *(5/17)*	43 *(12/28)*
Speaking Speaking	**71** *(27/38)*	**49** *(15/31)*	**49** *(19/39)*	**70** *(9/13)*	**36** *(6/17)*	**36** *(10/28)*
Vocalising	11 *(4/38)*	13 *(4/31)*	6 *(2/39)*	0 *(0/13)*	18 *(3/17)*	0 *(0/28)*

Notes:
Task 1[1] To construct an alternating tall and short pattern using 6 strips of green unifix cubes.
Task 2[2] To construct an alternating pattern using 6 strips of unifix cubes, of the same length (3 x black, 3 x white).
%[3] Percentage of total time coded action was observed during task. Values rounded up to nearest whole value.
(29/38)[4] Range for each action coded. Number of times action was observed out of total number of events observed across the task. (Events refer to the series of actions observed within a ten second timeframe).

Results

Results for Task 1(alternating ABAB tall and short pattern using green unifix) show firstly, looking at-object decreased marginally by 7%, secondly, looking at-researcher increased by 23%, thirdly, types of handling-actions were consistent, with the exception of handling-both hands which decreased by 21% and finally, speaking decreased by 22%.

What is noteworthy is that the relationship between the percentages of time spent looking at the researcher and speaking changed during P1 and P2. These types of actions increased or decreased together.

Results for Task 2 (alternating ABAB using black and white unifix) show that time spent looking at-object decreased by the same percentage as in Task 1. Time spent looking-at researcher remained similar and types of handling-actions showed greater variance. Handling-both-hands increased for P1 but decreased by 16% during P2. Handling-left-hand decreased by 19% between T3 and P2 and speaking decreased by 34%. Finally, the relationship between speaking and looking at-researcher changed to 36% for both actions.

Table 8.5 Actions - average time and range across all assessments: Percentage of time actions were observed during the first 15 minutes of the assessment.

Action	*Assessment average score*				
	T1 (%)[1]	**T2 (%)**	**T3 (%)**	**P1 (%)**	**P2 (%)**
Looking Object	80 *(50-100)*[2]	83 *(63-100)*	81 *(73-93)*	80 *(72-95)*	71 *(59-86)*
Researcher	**18** *(12-24)*	46 *(24-78)*	32 *(29-34)*	40 *(34-42)*	**43** *(19-58)*
Handling Pointing-at	9 *(0-24)*	0 *(0-28)*	3 *(0-8)*	1 *(0-2)*	2 *(0-5)*
Reaching-towards	1 *(0-3)*	1 *(0-5)*	0 *(0-0)*	1 *(0-2)*	10 *(0-15)*
Handling-both hands	5 *(0-18)*	13 *(0-30)*	14 *(0-29)*	14 *(7-24)*	7 *(0-15)*
Handling-right hand	**13** *(0-36)*	2 *(0-7)*	2 *(0-6)*	5 *(0-12)*	3 *(0-6)*
Handling-left hand	47 *(32-72)*	31 *(23-42)*	52 *(37-62)*	35 *(30-39)*	41 *(38-43)*
Speaking Speaking	**51** *(18-78)*	59 *(45-65)*	63 *(50-71)*	34 *(18-49)*	**40** *(15-53)*
Vocalising	6 *(2-39)*	4 *(0-13)*	6 *(0-11)*	33 *(6-30)*	20 *(0-15)*

Notes:
%[1] Percentage of total time coded action was observed. Values round up to nearest whole value.
(50-100)[2] Range for each action coded. Number of times action was observed out of total number of events observed across the task. (Events refer to the series of actions observed within a ten second timeframe).

Results

Results overall show that looking at-object was similar for T1 to P1 but decreased by 9% during P2 whereas looking at-researcher increased by 25% between T1 and P2. Reaching-towards increased by 9% and handling-both-

hands varied between 5% and 14%. Handling-right-hand decreased by 10% and handling-left-hand showed variances between 31% and 47%. Speaking varied but overall showed a decrease by 11% and vocalising ranged between 4% and 33%. What is noteworthy in these results is the reduction in handling-right-hand.

Literature suggests vocalisation is part of typical development in children. As well as being part of pre-linguistic language development (Locke, 1989), it helps children learn about the relationship between sound and emotions (Knudsen, 2008), it is used as a means of integrating singing with movement (Pond,1981) and for understanding the self, for example, Michel Foucault's 'technology of the self', (Foucault, 1986, 1988). Changes in the level of vocalisation and verbal monologues show the transition between Piaget's pre-operational and concrete-operational phase in psychological development (Piaget, 1959, pp. 256-257). However, contrary to Piaget's notion that vocalisation gradually disappears, Vygotsky (1962) held the view that it changes into inner mental dialogue.

A separate analysis of vocalisation (muttering/talking to self, humming and sound effects) was therefore undertaken to determine if this seemed to be related to Bob's attention level. Results presented in Table 8.6 shows the percentage of time vocalisation and off-task behaviour was observed during the first fifteen minutes of T1, followed by tables 8.7 to 8.10 for T2,T3, P1 and P2.

Table 8.6 T1: Percentage of time vocalisation and off-task behaviour was observed during the first 15 minutes of the assessment

Assessment and Behaviour	***Tasks - assessment score***						
T1	**Task 1 LT[1]`(%)[3]**	**Task 2 LT(%)**	**Task 3 LT(%)**	**Task 4 HT[2](%)**	**Task 5 LT(%)**	**Task 6 LT(%)**	**Task 7 HT(%)**
Vocalising	5	0	15	19	12	**0**	*23*
off-task	53	0	10	31	8	**52**	31

Notes:
LT[1] Tasks dependent upon looking, as the predominant action, for successful completion
HT[2] Tasks dependent upon handling, as the predominant action, for successful completion
%[3]Percentage of total time coded action was observed during task. Values round up to nearest whole value.

Table 8.7 T2: Percentage of time vocalisation and off-task behaviour was observed during the first 15 minutes of the assessment

Assessment and Behaviour	***Tasks – assessment score***						
T2	**Task 1 LT[1](%)[3]**	**Task 2 LT(%)**	**Task 3 HT[2](%)**	**Task 4 LT(%)**	**Task 5 LT(%)**	**-**	**-**
Vocalising	5	0	13	0	0	-	-
off-task	7	9	11	13	40		

Notes:
LT[1] Tasks dependent upon looking, as the predominant action, for successful completion
HT[2] Tasks dependent upon handling, as the predominant action, for successful completion
%[3]Percentage of total time coded action was observed during task . Values round up to nearest whole value.

Table 8.8 T3: Percentage of time vocalisation and off-task behaviour was observed during the first 15 minutes of the assessment

Assessment and Behaviour	***Tasks-Assessment score***						
T3	**Task 1 HT[1](%)[2]**	**Task 2 HT(%)**	**Task 3 HT(%)**	**Task 4 HT(%)**	**-**	**-**	**-**
Vocalising	11	0	8	6	-	-	-
off-task	7	7	10	40			

Notes:
HT[1] Tasks dependent upon handling, as the predominant action, for successful completion
%[2]Percentage of total time coded action was observed during task. Values round up to nearest whole value.

Table 8.9 P1: Percentage of time vocalisation and off-task behaviour was observed during the 15 minutes of the assessment

Assessment and Behaviour	***Tasks-Assessment score***						
P1	**Task 1 HT[1](%)[2]**	**Task 2 HT(%)**	**Task 3 HT(%)**	**-**	**-**	**-**	**-**
Vocalising	13	**18**	6	-	-	-	-
off-task	10	**0**	30				

Notes:
HT[1] Tasks dependent upon handling, as the predominant action, for successful completion
%[2]Percentage of total time coded action was observed during task. Values round up to nearest whole value.

Table 8.10 P2: Percentage of time vocalisation and off-task behaviour was observed during the first 15 minutes of the assessment

Assessment and Behaviour	***Tasks-Assessment score***						
P2	**Task 1 HT(%)**	**Task 2 HT(%)**	**Task 3 LT[1](%)**	**Task 4 HT[2](%)[3]**	**Task 5 HT(%)**	**Task 6 HT(%)**	**-**
Vocalising	6	0	5	15	0	0	
off-task	3	5	0	14	4	0	

Notes:
LT[1]Tasks dependent upon looking, as the predominant action, for successful completion
HT[2] Tasks dependent upon handling, as the predominant action, for successful completion
%[3]Percentage of total time coded action was observed during task. Values round up to nearest whole value.

Results

The results show that the percentage of time vocalising was highest during P1 Task 2. When the percentage of off-task behaviours was highest during T1 Task 6 (52%) there were no recorded vocalisations and vocalisation was higher during handling-actions across the intervention.

Summary

These results show that looking at-objects across the intervention was consistently above 70%. The most noteworthy change in types of handling-actions was an overall decrease in handling-right-hand. The percentage of time spent looking at-researcher increased when Bob was conversing with the researcher. Whilst vocalising was higher during handling-actions it did not increase off-task behaviours.

Interpretation

Overall, these results show a change in the pattern of actions across the intervention; notably, Bob increasingly looked at the researcher when speaking. There was no evidence to show a pattern of increased vocalisation during off-task behaviour, or of it impeding on-task attention levels. This is in line with suggestions in the literature referred to above, that vocalisation has a developmental role. Thus we would not expect it to be a reflection of lack of engagement.

8.7 Sequences of actions

The next set of results show the changes in sequences of actions across the intervention. The first five minutes of the first intervention session were compared to the first five minutes of the final intervention session. Results are illustrated in Table 8.11 and Table 8.12 below. All sequences start with a looking-action because handling-actions are typically visually-directed.

Table 8.11 Number of times a sequence of actions occurs in a 5-minute timeframe

Sequence of actions[1]	*Intervention session*	
	First five minutes of session	**First five minutes of final session**
Looking Handling Speaking	8	**14**
Looking Handling Speaking Handling	1	0
Looking Handling Speaking Handling Speaking	1	0
Looking Speaking Handling	2	0
Looking Speaking Handling Speaking	1	0
Looking Speaking	7	**13**
Looking Handling	11	9
Total number of sequences	31	36

Notes:
Sequence of actions[1] Different combinations of actions observed in both sessions.

Table 8.12 Order of observed sequences in handling-task

Intervention and Week

First intervention session **Or*der of sequence*[1]**	***Last intervention session*** ***Order of sequence***
Looking Speaking Handling Speaking	Looking Handling Speaking
Looking Handling Speaking	Looking Handling X 2
Looking Handling	Looking Handling Speaking
Looking Handling Speaking	Looking Handling X 3
Looking Speaking Handling	Looking Handling Speaking X 7
Looking Speaking	Looking Handling X 3
Looking Handling X 2[2]	Looking Speaking
Looking Speaking	Looking Handling
Looking Handling	Looking Handling Speaking X 3
Looking Handling Speaking x 2	Looking Speaking X 2
Looking Handling Speaking Handling	Looking Handling Speaking X 3
Looking Handling X 4	Looking Handling X 4
Looking Speaking	Looking Handling Speaking X 3
Looking Handling X 2	Looking Speaking
Looking Handing Speaking Handling Speaking	Looking Handling X 2
Looking Handling Speaking X 2	Looking Speaking
Looking Speaking	Looking Handling X 2
Looking Handling Speaking	Looking Handling Speaking X 2
Looking Speaking X 3	Looking Handling
	Looking Handling Speaking X 2
	Looking Handling X 3
	Looking Speaking
	Looking Handling
	Looking Speaking
	Looking Handling X 3

Notes:
Order of sequence[1] Observed sequences during first five minutes of a handling-task
Looking Handling X 2[2] Repetitions of the same sequence

Results

A change in the sequence of actions occurred; actions in the last intervention session followed a structured pattern of looking then handling, looking and handling then speaking, and looking and speaking.

Summary

The first session started with eighteen sequences of looking and handling. This increased to forty-seven in the last intervention session. Results show a decrease in the number of *different types* of sequences.

Interpretation

The increased number of repetitions of the same sequences of actions suggests Bob is approaching the cognitive demands of tasks in a more thoughtful way. It may imply that Bob is thinking and planning patterns whilst he handles the resources.

8.8 Motor actions

The final results presented in Table 8.13 relate to motor-actions. This was to establish if any changes were evident from the pre-intervention typography of movement to the final phase of the delayed post-intervention assessment.

Results

Results show that when transferring objects from one hand to the other, right-to-left hand is marginally higher than left-to-right hand. When objects were placed on Bob's front-right or right-side, however, use of the right hand did not increase. Instead, Bob reached across with his left hand.

Summary

During the typography of movement assessment there were no recorded observations of Bob using his right hand on its own. During the intervention, results show consistent (though infrequent) right hand use.

Interpretation

Of note, handling with both hands was much less frequent during the intervention sessions than during the assessments. This could be due to less time using playdough and more time using ready-made resources during the assessments. The ready-made resources were easier for Bob to access using his left hand whilst the making of resources using playdough (sausages/balls) necessitated using both hands.

Table 8.13 Average time for location of task and hand-use across all assessments

Location/ Action	*Assessments and intervention sessions (TS)* [1]							
	T1 (%)[2]	**TS1 (%)**	**T2 (%)**	**TS2 (%)**	**T3 (%)**	**TS3 (%)**	**P1 (%)**	**P2 (%)**
Location Front	28 *(0-67)[3]*	-[4]	23 *(5-47)*	-	24 *(19-31)*	-	15 *(7-20)*	12 *(0-29)*
Front Right	21 *(4-36)*	-	9 *(0-30)*	-	5 *(0-8)*	-	0 *(0-0)*	8 *(0-21)*
Right	16 *(0-36)*	-	13 *(0-34)*	-	23 *(16-34)*	-	2 *(0-5)*	9 *(0-35)*
Front Left	10 *(0-18)*	-	24 *(0-41)*	-	14 *(6-31)*	-	29 *(23-36)*	20 *(4-34)*
Left	*6* *(0-22)*	-	24 *(6-40)*	-	23 *(8-40)*	-	25 *(12-42)*	10 *(0-22)*
Handling Handling-both hands	7 *(0-18)*	2 *(0-4)*	13 *(0-30)*	5 *(0-16)*	14 *(0-29)*	3 (0-12)	15 *(7-24)*	9 *(0-15)*
Handling-right hand	13 *(0-35)*	4 *(0-11)*	2 *(0-7)*	1 *(0-8)*	2 *(0-6)*	1 (0-5)	5 *(0-12)*	3 *(0-6)*
Handling-left hand	47 *(32-72)*	32 *(19-50)*	31 *(23-42)*	38 *(0-60)*	52 *(37-62)*	24 *(0-65)*	35 *(30-39)*	41 *(39-43)*
Transfer-right-left hand	1 *(0-1)*	1 *(0-10)*	2 *(0-3)*	1 *(0-3)*	1 *(010)*	0 *(0-0)*	0 *(0-0)*	0 *(0-0)*
Transfer-left-right hand	1 *(0-2)*	1 *(0-3)*	0 *(0-0)*	1 *(0-2)*	1 *(0-3)*	0 *(0-0)*	0 *(0-0)*	0 *(0-0)*

Notes:
Assessment and TS score[1] Location and action across each assessment.
(%)[2] Average percentage of total time coded action was observed. Values round up to nearest whole value.
(0-67)[3] Range for each action coded.
-[4] Data not recorded.

8.9 Summary

The results suggest that the intervention was successful in effecting a change in sustained attention. This was evidenced by four types of improvement. Firstly, decreased episodes of off-task behaviours from 27% in T1 to 7% in P2,

secondly, a reduction in the total number of researcher prompts to redirect Bob's attention. These decreased from twenty-eight during T1 to five during assessment P2. Thirdly, increased actions appropriate to the task changed across the intervention. Specifically, the percentage of time Bob was looking at the researcher whilst speaking changed from 18% and 51% respectively, during T1 to 43% and 40% during P2. Finally, increased number of repetitions of the same sequences of actions suggested that Bob was approaching the cognitive demands of tasks in a more deliberate way. The number of sequences of looking, handling, speaking increased from eight to fourteen; and sequences of looking, speaking changed from seven to thirteen. Thus, there was an increase in the extent to which Bob was talking to the researcher about what he was doing and increased looking at the researcher showed his engagement.

Chapter 9: Discussion

9.1 Introduction

This chapter starts by relating the findings to the research questions and showing how the findings support answers to those questions. This is followed by a discussion of factors that supported the success of the intervention. The results are considered in relation to the existing body of knowledge in this field. Following this, alternative explanations of the results are considered and any unexpected findings. Strengths and limitations of the present research are considered followed by the contribution within the field, further research and the dissemination of findings.

9.2 Research question 1: Can the attentional capacity of a child with CP be improved?

For the purpose of this study, a 'sustained' attentional difficulty was defined as difficulty in maintaining a constant behavioural response over time when involved in a continuous and repetitive activity (Kerns and Mateer, 1996). Engagement was defined as 'on-task behaviours' and these were used as a measure of Bob's attention.

The findings demonstrated that across the course of the intervention longer episodes of continuous on-task behaviours occurred. Thus, this study demonstrates that the attentional ability of a child with cerebral palsy *can* be improved. Bob's on-task behaviours increased by 20% from T1 to P2. In addition to the overall decrease in off-task behaviours across the intervention, the number of different types of off-task behaviours decreased from eleven during T1 to five during P2. The number of researcher prompts to support attention also decreased. During T1 a total of twenty-eight prompts were recorded which decreased to three during P2. This was not only because on-task behaviours had increased but also because Bob was starting to re-direct his attention to the task following distractions.

9.3 Research question 2: What approach is needed to develop early mathematical understanding for a child with CP?

Although an assessment of Bob's mathematical understanding was undertaken before the intervention commenced, (outlined in Chapter 4 section 4.3) the full nature of Bob's difficulties only emerged during the intervention. Fortunately, as described in section 5.3, page 123, it was possible to adapt sessions so that the focus was on non-numerical patterns that nevertheless had simple mathematical properties. This ensured that any difficulties Bob was shown to have with such mathematical patterns was not due to arithmetical difficulties. Opportunities to experience a range of simple pattern sequences, using colours and shapes, enabled Bob to develop early mathematical understanding, consolidating his learning through repetition and practice. This is recommended for all early mathematics teaching of children with cerebral palsy who have number difficulties. It follows that early assessment of number ability is, as proved to be the case with Bob, essential.

9.4 Practitioner reflections relating to Research questions 1 and 2

In addition to increasing Bob's attentional capacity, the intervention was successful in developing Bob's early understanding of mathematical relationships through developing pattern awareness. The intervention supported Bob to understand the term 'pattern', learn to copy repeating patterns and begin to recognise that regular patterns follow rules. In addition he was able to follow rules to continue repeating patterns and to devise simple repeating patterns.

By gradually increasing the difficulty of tasks and changing the variables, it was expected that engagement would be maintained and attention extended. From careful practitioner observation of Bob throughout the course of the intervention sessions, supplemented by intensive and repeated viewing of the video footage of the same sessions, it became possible to discern when increased challenge was needed. Video recording was important because during the actual sessions, my attention was divided between Bob and the delivery of the planned tasks including: the organisation of resources, placement of objects and ensuring that consistent language (including vocabulary) was used. Repeated viewings of the recordings also enabled me to concentrate solely on

Bob's behaviours and responses. During initial viewings my focus was distracted by critical reflection on myself as a practitioner and occasions when my own responses may have been a hindrance, for example, by intervening too quickly and not allowing enough time for exploration of resources during some tasks. But this could be used to advantage. Repeated viewings focused on teaching and interactions also enabled me to improve my own practice. For example, video evidence suggested that Bob seemed to benefit from the exploration of materials which had originally been planned as a reward at the end of every session. Therefore, exploratory play allowed at the start may have reduced the off-task behaviours which arose from episodes of fiddling/playing with resources.

9.5 Factors that supported the success of the intervention: implications for practitioners

I have reflected upon the aspects of the intervention that led to successful outcomes based upon the findings. Across the intervention, on-task behaviours were consistently highest (93% - 100%) for tasks involving unifix cubes and an ABAB alternating pattern rule. Colours for these tasks were blue/white, black/white, pink/brown, and the tall/short alternating pattern used green cubes. The two tasks across the intervention when off-task behaviours were lowest (below 45%) both involved coloured wooden shapes. One involved an ABC alternating pattern rule and the other required Bob to devise his own pattern. However, when asked to continue an alternating ABC pattern using wooden shapes during the P2 assessment, Bob was on-task for 96% of the time and self-corrected without prompting. As three-dimensional resources were common to all these tasks, the number of variables seemed to be key to his engagement rather than the resource. When the demands of the task were too high Bob's engagement decreased.

When reflecting upon the intervention as a teacher practitioner I was able to see tangible progress in a number of Bob's skills and his ability to engage in learning. The approach taken to the intervention was based upon a range of practical resources which provided scope for Bob to handle and manipulate materials with differing properties. Findings showed an increase in exploration of resources across the intervention and for Bob, this seemed to be an

important aspect of his learning. Results indicated this was the mechanism to improving attention and through increased attention an improvement in cognition and learning was secured.

9.6 Recommendations for the support of children with CP

A major purpose of the study was to identify features of the tasks that could be usefully adopted by teachers in devising other tasks to help children with CP. This section examines the general, replicable features of the tasks that teachers should attend to including: the administration of tasks, the behaviour of the teacher, the conduct of teaching assistants, the choice of resources and the tasks.

Structure

Sessions involving a series of short activities and repetition of concepts were repeated throughout the session using a range of different resources. Opportunities to handle the resources were planned at the end of sessions but may have been more beneficial at the start. A balance between following the child's line of enquiry through exploration of resources and achieving the learning objectives planned for the session needs consideration. It may sometimes be more beneficial to go off-task and focus on exploration of properties and developing imaginative play if this is a gap in the child's development.

The repetition of the same concepts planned across the intervention using different resources provided scope to consolidate learning. Whilst this is standard good teaching practice for all children the experiential aspect of the sessions proved especially important for Bob. Tasks were administered as a series of separate activities with a focus on one pattern rule which was repeated across the activity. Pattern concepts were reinforced using multisensory learning and the level of challenge increased to build upon success.

The role of the practitioner

There were occasions when Bob was engrossed in exploration of objects but limited time meant that he was re-directed to attend to the features of the tasks planned for the session. Thus, if the child is engrossed in exploration of

objects, it is appropriate for the supporting adult to observe quietly and without interrupting. However, discreet support with re-positioning of resources is beneficial if the child is experiencing motor difficulties which may cause feelings of frustration. When off-task, discretionary prompts to re-focus the child's attention is supportive. For example, repetition of instructions, pointing to resources to encourage visual attention, questions or statements to acknowledge an action carried out, or repeating the child's name to gain attention.

Focused support to increase self-esteem is especially important for children with CP this is because literature presented in Chapter 2, page 46, claimed social and emotional difficulties relating to motor impairment and disability are common. Interactions with Bob focused on supporting his attention using prompts and allowing time to explore the objects, albeit more time may have been beneficial.

Communication and language

Reliance on understanding language was minimised and alternatives used including gesture to point at resources or the next step in a pattern. This allowed Bob to communicate his thinking using gesture whilst he built up the vocabulary to explain his patterns using words. Minimising language allowed Bob time to focus on the visual aspects of an activity without having to additionally process language. Language was repeatedly modelled across the intervention and key terms revisited at every session. Concepts were taught using a multisensory approach to learning[59] including visual, auditory and kinaesthetic/tactile (doing practical activities). These were reinforced using the same multisensory approach, for example by saying 'blue, white, blue, white' at the same time as pointing to the corresponding shape and also asking Bob to say the pattern with me.

During my experience of working with the five children with CP as part of my advisory role, and then with Bob during the present study, I noticed that some had become adept at using strategies to mask comprehension difficulties. This was achieved by the children leading conversations around topics they were

[59] The theory that individuals learn better if they are taught using more than one sense

interested in, or by asking random questions, unrelated to the task to divert my attention. A fuller study of language use in such a context is worthy of a project of its own.

Resources and materials

When specialist seating has been recommended by health professionals it should be used so that the child is positioned at the right height for optimum physical and visual access. In addition to this, the placement of resources needs consideration to enable access. This includes both the length of the child's reach and positioning resources on the child's apposite functional side. The use of strong visual contrast when using coloured resources may help to support possible undiagnosed visual perceptual difficulties in children with CP. Whilst space is often an issue within many schools, interventions should be undertaken in an environment with minimal distractions. This includes the flow of people, noise and visual clutter, for example, resources that are unrelated to the task are not on display.

Literature reviewed earlier suggested a possible link between the development of mathematical skills and the importance of motor experiences, including tasks requiring eye-hand coordination and grasping (Arp and Fagard, 2001). Number processing and physical movement are thought to be linked but motor difficulties can restrict required motor experiences (Van Rooijen, Verhoeven and Steenbergen, 2011). Subsequently, whilst concrete objects (things they can touch and move around) are beneficial to all to children, children with CP affecting upper body and arm/hand function will require increased motor experiences. Therefore, opportunities to explore and manipulate objects to develop mathematical understanding are especially important for children with CP.

The intervention incorporated a range of resources with differing features including two/three-dimensional and pliable/inflexible materials. Findings showed that the feature of resources was an important factor in engagement levels. When planning learning objectives the resource should be matched to the overall aim of the session. For example, novelty objects increased object

play[60] and provided opportunities for the development of problem-solving skills and exploration of combinations of motor actions. This provides a focused investigation which helps the motor impaired child to gain familiarity with the properties of the resource and how to manipulate them. The Fimo clay increased off-task behaviour during the intervention sessions because Bob was focused on breaking the pieces to explore properties. Likewise, coloured wooden shapes increased off-task behaviours but would be beneficial for the development of imaginative play as a separate activity. This resource facilitated exploring combinations of shapes to represent things, for example, houses and peacocks. Bob appeared to enjoy the opportunity to make choices about the resources within the intervention sessions, including playdough cutter, colour and shape. Pliable materials increased opportunities for using both hands together and would be valuable for integrating hand function targets within a session. Whilst individual preferences will have a bearing on choice of materials, for Bob, ready-made resources that were similar apart from colour/length increased on-task behaviours and were successful for focused thinking about the pattern and rule.

The schedule devised for the typography of movement study can support teachers' planning and the allocation of resources. Understanding when the child will need targeted practical support and when the adult should step back will allow for the development of independent problem solving through trial and error. The schedule does not necessitate specialist materials and observations can be carried out during undirected play sessions within the classroom. If the use of video is not possible, the recording sheet can be adapted and ticks entered against the motor skills when observed in real time.

Of equal value to teachers is understanding the presentation of on-task and off-task behaviours for children with CP. A classification of off-task behaviours and their probable causes was essential in developing my understanding of how to support Bob. The schedule devised for this study can be adapted for use by teachers to establish behaviours characteristic to the child. The on-task and off-task behaviour recording sheet, devised for this study, has been successfully

[60] Playful use of objects

completed by a Special Needs Coordinator in a mainstream school for a child presenting with attentional difficulties. This observation provided valuable information to support a statutory assessment of need under the Code of Practice (2015) [61]

Fatigue and rest breaks

Episodes of fatigue relating to CP may need to be considered and flexibility within an intervention planned. New concepts should be introduced when the child is alert and opportunities for object play and imaginative play provided when the child shows increased off-task behaviours due to fatigue.

Some recorded instances of off-task behaviours were noted when Bob's postural control was poor. For example a total of 29% of off-task behaviours during T1 were recorded for this reason. Whilst practitioners cannot control the physiological aspects of a child with CP, understanding the implications within a learning environment is crucial. It may be appropriate to facilitate a rest or movement break, depending on the type of CP the child has. Within a busy mainstream setting, time for moving and handling procedures needs to be considered so that opportunities for social development are not missed. A balance between using breaks and using formal learning times to accommodate moving and handling routines and physiotherapy programmes needs to be achieved.

9.7 How the results relate to the existing body of knowledge

The literature presented earlier demonstrated a gap in knowledge in respect of strategies and evidence-based educational interventions to support the learning of children with CP. Results from educational studies offered widely different focuses some highlighting difficulties of attention and WM whilst others emphasized associated behavioural and motor impairment. The diffuse nature of these findings seemed to offer little that was of immediate use to practitioners. The present study therefore sought 'real world' knowledge of CP in an educational context by focusing on systematic and repeated observation of a single child with CP. The focus was on sustained attention, and an

[61] Last updated

educational methodology was used that enabled sustained attention specifically to be assessed and trained over an intervention period.

The findings of the present study indicate that associated motor impairment was not a factor in Bob's observed attentional difficulties, although some literature (Heinen et al., 1999; Leonard et al., 1990; Leonard et al., 2006; Vry et al., 2008) suggests that Bob's motor impairment may have been a factor in early acquisition of attentional control, that is, his ability to select what to pay attention to and what to ignore.

This research echoes Vygotsky's position that for children with disabilities learning takes place within an environment that provides alternative modes of communication. Additionally, development takes place within their 'zone of proximal development' (the difference between what the child can do without help and what can be achieved with help). It was occasions across the intervention when this was right that Bob was able to sustain attention and make progress.

Bob benefited from a planned intervention targeted to develop attentional control conducted out of the classroom setting. However, the social element of learning became increasingly apparent as sequences of actions altered and meaningful turn-taking conversation increased, as opposed to instances of talking out loud, but without apparent expectation on Bob's behalf of gaining a response.

Motor impairment reduced Bob's choice of activities during his formative nursery years and decreased the amount of time spent playing with or alongside his peers as he was reliant upon an adult to facilitate physical access. Therefore supporting infants to access typical learning experiences through early intervention programmes is important (Woolfson, 1999).

9.8 Evaluation of alternative explanations of the results and unexpected findings

Although the variation in types of off-task behaviours decreased across the intervention, the recorded incidences of *x(d) ignoring a question and fiddling with resources*, increased from thirty during T1 to seventy-three during P2. This was a surprising result as a reduction was anticipated. It was assumed that an

improvement in motor memory through repetition and practise with the resources and tasks would result in a reduction in fiddling.

Vocalisation

Prior to data analysis I had anticipated that episodes of vocalisation signalled poor concentration and increased off-task behaviours. However, results did not support this assumption as there was no association between the number of recorded vocalisations and incidences of off-task behaviours. Vocalising did increase during handling-actions. Both Piaget (1959) and Vygotsky (1962) suggest that vocalisation has a role to play in development and learning.

Use of right hand

A surprising finding was the decrease in handling-right hand across the intervention. At the start of the intervention it was anticipated that an increase would be noted due to the practical nature of activities and the planned opportunities to rehearse motor movements. Recent research indicates that intensive motor training of the unaffected hand to maintain dexterity is related to cognitive performance in school-aged children with CP (Thébault, Martin, Brouillet, Brunel, Dinomais, Presles, Fluss, and Chabrier, 2018). The practical intervention used in the present study provided opportunities to preserve movement on the less affected left side. This was facilitated by allowing Bob to decide which hand to use throughout the intervention even if he reached across his body to grasp objects located on his right side. It is possible that a reduction in Bob's right hand use was related to increased cognitive performance.

Actions

The results distinctly demonstrated an increase in the time Bob spent looking at the researcher when speaking. The short space of time needed for this change was unexpected. It suggested increased understanding of the language used by the researcher, and Bob's confidence to articulate his reasoning using words rather than gestures, typically pointing at objects. It could have resulted from increased familiarity with the researcher and confidence to engage in a conversation.

A surprising finding was that performance was not improved through repetition of the same task (see Figure 6.1, page 142) and furthermore, attention was not adversely affected by the length of time taken to complete any task. This suggests that engagement may have increased when tasks were more cognitively challenging but within Bob's capability. This possibility is supported by results that demonstrated increased engagement during some tasks despite poor performance (for example, T2 Task1).

9.9 Strengths and limitations of the research

It is worth considering what additional information might have been obtained if an ABA withdrawal design had been used for this study. An ABA withdrawal design (Campbell and Stanley,1966; Gast and Ledford, 2014) would have imposed an intervention which was more rigorously worked out beforehand so that the variables were better controlled. This would have enabled greater confidence in the role played by the intervention in the outcome of the study. It would also have offered a better chance of reproducibility. Firstly, there would have been an invariable baseline (at A_1, A_2 and A_3). Secondly, implementing a shorter interval between the first baseline (A_1) and the withdrawal phase, and similarly for subsequent phases of the intervention, would have reduced any effect of intervening variables and thus improved confidence in any associations found. Thirdly, devising an outcome measure which was more consistent with the baseline measure and the intervention assessment measures, would have helped identify those parts of the intervention that had marked or less marked effects on the outcome.

Finally, ABA withdrawal design attaches great importance to the numerical measure adopted. In the present study, the main numerical measure was time, specifically, percentage time on task, measured in seconds. Two considerations concerning time are suggested here: a) Not time, but *count* data could be used in future work. A count of on-task or off-task behaviours would not require noting the time of the start and end of time on-task. Counts would be more practical to carry out and would make it easier to avoid errors; hence the data would be safer. b) With more time at the researcher's disposal, the video records could be viewed for longer than the first 15 minutes of each

session, and more intensively, than allowed in the current study. This would provide more data and so strengthen conclusions drawn from it.

The pressures of everyday life in school made it impossible to implement a strict ABA withdrawal design. However, the action research actually undertaken was arguably of more benefit to the teachers whom it was designed to support, for that very reason. The various adjustments made were typical of those that life in school and the needs of the participant imposed, and the conduct of the present research under these conditions did provide an example of concern for rigour that might benefit any action researcher in school who reflected on it.

Limitations of the study as conducted

The adjustments made, and the reasons for them, were explained in the Method chapter, page 53. The limitations these adjustments imposed are now discussed.

In the study as actually conducted data collection conditions varied. The time of day was consistent, but the location of the intervention varied. The impact of this on the results is noted in section 6.4 at page 162. Nevertheless, the same behaviours were measured repeatedly and distinct patterns in Bob's behaviour over time were clearly identified.

While the baseline phase generated a range of important observational data which informed the planning of the intervention, only one measurement point was taken for time on-task and off-task. Therefore a stable measure with limited variability was not established to provide a benchmark for comparison of Bob's behaviour in subsequent phases. In addition, a clear trend of improvement was not generated to predict behaviour change resulting from the intervention. It was expected that the measure of attention, the dependent variable, would increase as a result of the intervention and therefore a decreasing trend during baseline would not be problematic. In the present study the five baseline measurement points (T1, T2, T3, P1 and P2) showed variance in the trend line. There was a gradual increase in time on-task across the intervention but a decrease in time on-task was evidenced at P1. Variability in this instance was attributed to tiredness rather than a predicted trend which

would have been determined if a longer baseline at the initial T1 assessment had established stability. An ABA withdrawal design typically recommends a minimum of three baseline data points to establish dependent measure stability (Kazdin, 2010). Whilst three assessments followed each withdrawal phase (B_1, B_2, B_3) only one measure was taken. However, to establish stability before progressing to the implementation and re-implementation of the intervention phase (A1, A2, A3) longer baseline phases were necessary with several measurements taken over different days to establish stability. This would have supported predictions about trends in the data as opposed to practitioner expectations which were not grounded in the data. Establishing a stable baseline would have provided a benchmark to assess the effects of the intervention including predicted changes to the dependent variable.

Based upon an ABA withdrawal design, a further improvement may have resulted from obtaining an average rate of performance during a phase to determine differences between the baseline and intervention phase. This is based upon the assumption that the dependent variable being targeted is reversible and will return to pre-intervention levels during the intervention withdrawal phase. However, as the aim of the intervention was to improve Bob's attentional ability, a generalisation across different learning domains was anticipated and because a permanent change in Bob's attentional ability was expected from the intervention, a return to baseline performance was not feasible.

A further limitation arose from possible effects of nuisance variables which may have decreased time on-task, these included adults entering the learning space and creating environmental distractions which were not controlled. Adhering to the procedures of an ABA withdrawal design may have addressed the effects of nuisance variables by demonstrating that systematic changes in time on-task resulted from the intervention. Therefore, the design of the present study may have been improved by incorporating extended measurement of the dependent variable during each baseline to establish patterns of responding. This would have enabled a comparison of performance during the baseline and intervention phase as set out in Gast and Ledford's (2014) guidelines outlined previously.

A further limitation arose from introducing more than one independent variable at a time. For example, the resources used throughout the intervention were changed within sessions but were not controlled. This meant that a number of variables, including differing textures and colours, were introduced at the same time. By modifying more than one variable at a time it was not possible to isolate factors that changed on-task or off-task behaviours. However, analysis of data showed distinct patterns of engagement based upon the types of resources used. Inferences were drawn "about functional relationships between independent variables and measured behaviours" (Wolery, Dunlap and Ledford, 2011, p.103).

Another confounding factor arose from changes in the cognitive demands of tasks when they were introduced simultaneously with new resources. A strength of adopting an action research approach enabled flexibility within the plan, do and review cycle and facilitated, "the active and deliberate self-involvement of the researcher in the context of his/her investigation" (McKay and Marshall, 2001, p. 49). This approach was an important aspect of practitioner-based research and enabled necessary changes to be implemented in response to my assessment of Bob's understanding at each point of the intervention and when problems arose.

Improvements could have been made by incorporating into the analysis the relative size of any changes, by marking the start of changes, and by indicating the trend or stability of outcome measures and presenting these in the visual displays of results.

Despite the limitations discussed, a strength of the design used was in providing scope to undertake a series of systematic observations. As described in the Method chapter, section.3.5, the pre-intervention assessment phase provided an opportunity for Bob to become familiar with both the resources and researcher prior to the start of the intervention. The typography of movement established that Bob would be physically capable of carrying out the planned activities and that the resources would be accessible to him during the intervention.

Reflection as a researcher has highlighted the need to spend more time in the initial planning stages of a study. Time limitations for the intervention, due to the demands of my job role, created a sense of pressure and the informal assessment of mathematical understanding using Numicon was too rushed. Later difficulties would have been avoided if a thorough assessment had been undertaken using additional resources and activities to check Bob's understanding of number.

To compare time on-task across the intervention the length of time spent on each task had to be equalised as far as possible. This meant that there were constraints on allowing Bob to tackle tasks in his own way. As a result valuable insights into his approach to learning may have been missed. For example, Bob's imaginative play with the wooden shapes was discouraged as the *planned* task was the focus in the time available. To address this is the future the child could have opportunities to play with the resources before each task and an additional code could be used to record episodes of imaginative play.

Time on-task is likely to be a fundamentally important variable in work with children with this type of SEN. But time on-task can be confounded with time taken to do the task. This is an important problem for research in this area, to which more attention needs to be given.

Due to the demands on space there was no control over the available working environment. Whilst the school was largely able to accommodate the intervention in the same room, there were occasions when parental meetings took precedence. Some sessions were therefore undertaken in alternative spaces including the dining hall and staff room. This meant I had no control over some variables and time on-task and off-task for identical tasks might have varied for reasons unrelated to the task itself. In fact results did show increased off-task behaviours, due to interruptions, when working in these spaces. On the other hand, an unplanned advantage arose from the opportunity to record instances of off-task behaviours in an environment closer to a typical classroom with noise and interruptions. In fact the results showed that Bob's ability to return to task after an environmental interruption improved across the intervention.

The intervention sessions were planned to take place on a weekly day and time that would cause least disruption to Bob's other timetabled activities. This meant that sessions took place even when it was evident that Bob was not in an optimum learning state. For example, during P1 it was apparent that he was tired and having difficulty sustaining attention. This factor adversely affected the results as it could not be controlled. Ideally, the session would have been postponed and rescheduled when Bob had adjusted to school after his holiday and was feeling less tired.

Although CP is a condition with highly individualised effects, and although this was a single-case study, it nevertheless provides a template for future assessments and interventions with individuals, particularly for classroom practitioners.

The main methodological challenge arose from the repetitious nature of the tasks and the risk of improved outcomes resulting from practise effects. To address this possible limitation, different variables were used to assess whether a concept had been understood and generalised when presented with differing numbers of components and elements. This included the total number of rows, shapes and colours involved in a pattern and the features of a resource, for example, two-dimensional /three-dimensional; flexible/inflexible.

Although I met with parents and explained the study to them, it was not made explicitly clear *in writing* that no adverse consequence would result from declining permission for the research.

Limitations to the interpretation of the results

This study was designed with an unambiguous measure of attention in terms of on-task behaviours. These were coded according to a clear set of pre-determined criteria decided upon during the pre-intervention assessments. The researcher's qualitative observations proved invaluable in interpreting the quantitative data so as to make sense of anomalies, but interpretation was necessarily limited to observed behaviours.

9.10 Further research

Further research is needed to support teachers to know how they can plan and adapt their educational strategies to include learners with cerebral palsy. The literature review highlighted a number of difficulties which would benefit from further research. These included language difficulties, possible visual deficits and social interaction. A study which focused on supporting a child with cerebral palsy to develop their attentional ability using literacy as the focus of the intervention would be valuable.

Future studies might take a different approach in attempting to explore thinking processes through discussion and questions. In the present study understanding formal language and vocabulary appeared to be an area of difficulty for Bob. Nevertheless, a more conversational enquiry could have been beneficial, even if made rather difficult because of his language and processing difficulties.

9:11 Contribution within the field

Despite the limitations of the present study it provides an original contribution within the field of disability studies in education. Whilst focusing on the development of the attentional ability of a child with CP several important issues have emerged around inclusion, including facilitating access to the environment and learning within a social context with peers.

The principles of 'inclusion' set out in the National Curriculum (DfE, 2014) include:

- setting suitable learning challenges
- responding to pupils' diverse learning needs
- including all learners by overcoming potential barriers to learning and assessment.

Unless difficulties are assessed and addressed, appropriate learning objectives cannot realistically be planned. As evidenced in the present study, Bob was able to make measurable progress when the right resources and tasks were matched to his current learning needs.

The present study has highlighted a number of educational challenges in meeting the needs of children with CP. Ongoing assessment and evaluation is imperative to ensure the child's potential is being recognised. Learning activities, including resources matched to the child's developmental stage, are essential to address gaps in the acquisition of skills. The literature review has demonstrated how attention is the fundamental building block for cognitive development (see section 2.3, page 28). For children like Bob, deficits in attentional control need to be explicitly addressed as a starting point for the development of intrinsic motivation and learning how to be a lifelong learner. Reflections outlined earlier, regarding the limitations of this study, have highlighted a need to understand how children with attentional difficulties learn.

The success of this research was essentially founded on Vygotsky's theory (ibid) and the principle of scaffolding and the zone of proximal development. Through careful ongoing observation I started to understand (albeit sometimes retrospectively), what Bob could do on his own and what to do to support tiny steps of progress. This was achieved in a social context whereby a shared experience was created, especially when using the playdough as a resource. This generated discussion, language development and Bob's independent problem-solving skills.

Of particular benefit to me as a practitioner were the opportunities to view and discuss the video recordings with two experienced university researchers. Consequently, purposeful viewings and discussion of videos of teaching children with CP, jointly with the teaching assistant, is a recommendation of the study.

9.12 Conclusion

This research has influenced the way I approach my advisory role within Children's Services. I have moved away from the practice of writing recommendations in reports to directly working with and alongside teaching assistants to model ways of working with the children. This has far more impact and provides an opportunity to raise awareness of how to support the child by scaffolding learning. It also enables teaching assistants to reflect upon where the child is through observation and discussion. Gaps in development,

highlighted throughout this study, need to be addressed so that a strong foundation can be established. In the case of Bob, the intervention enabled him to learn how to re-direct his attention back to a task following distractions and without adult prompts. This demonstrated that Bob was developing the skills needed to be an independent learner including intrinsic internal motivation.

The convention on Rights of Persons with Disabilities (2006), aimed to promote, defend, and reinforce the human rights of all persons with disabilities, including the right to an inclusive education. Article 24 (CRPD, 2006) states:

(d) Persons with disabilities receive the support required, within the general education system, to facilitate their effective education;

(e) Effective individualized support measures are provided in environments that maximize academic and social development, consistent with the goal of full inclusion.

The discussion of the present study has highlighted the need for inclusion of children with CP by facilitating both environmental and social access to learning activities. The literature reviewed in Chapter 2 highlighted difficulties around social inclusion, participation and peer relationships. Additionally, anxiety was attributed to disability and issues around appearance and self-worth. These combinations of factors were considered influential on behaviours including motivation, which is important in the development of attention.

Legislation and statutory guidance provide both a legal framework and advice to support the inclusion of children with disabilities in society. Examples include:

- SEND Code of Practice (2015)
- The Equality Act (2010)
- Children and Families Act (2014)
- Working Together to Safeguard Children (2018)
- Reasonable adjustments for disabled pupils (2012): Technical guidance from the Equality and Human Rights Commission
- Supporting pupils at school with medical conditions (2014): statutory guidance from the Department for Education.

However, increasing numbers of children with SEND attending state secondary schools in England fell by 8% between 2010 and 2018 (The Guardian, 2019), whilst the numbers of exclusions[62] and 'off-rolling'[63] increased. This demonstrates that systems are failing many children and further educational research is needed to fully understand their unique needs and how to support their attainment. The present study demonstrated how a child with CP was able to increase his attentional capacity and start to develop early mathematical understanding. My understanding as a researcher and practitioner was reached through hours of observation of Bob's behaviours. The expertise of two experienced university researchers ensured that the interpretations made of Bob were objective. This was achieved through watching extensive footage of different assessments and intervention sessions together and discussing our observations.

The findings demonstrate that policy and practice for the education of children with SEND is not consistently meeting their unique learning needs. Resources need to be appropriately targeted and practitioners trained to undertake the level of assessment required to identify gaps in learning and to address barriers to achieving successful outcomes. Learning should be targeted to meet the developmental needs of each child rather than on the delivery of a national curriculum aimed at typically developing children.

This research study has demonstrated that in the case of Bob, there were significant gaps in his development and learning and the intervention needed to be constantly stripped back and simplified in order for Bob to start to engage through sustaining attention. The intervention was successful in creating a learning environment that supported Bob to develop a more positive perception of his abilities. The early video footage showed a young boy who was hesitant in his responses and lacking motivation. By matching Bob's needs and abilities in a learning environment that encouraged active engagement using practical resources, he was able to improve his level of engagement measured through time on-task.

[62] Child removed from school and is not allowed to attend there for a certain number of days.
[63] When schools remove difficult or low-achieving pupils from their rolls so that they are not included in their GCSE results.

During the delayed post-intervention assessment Bob was able to re-direct his attention to task without adult prompts. This indicates that as well as improved attentional control Bob was motivated to learn.

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Appendices

Appendix One: Results of the Automated Working Memory Assessment

This is a fully automated computer-based measurement instrument of WM which incorporates national percentile ranks and standardised scores. The AWMA includes tasks to assess the following components of WM:

Verbal short-term memory

These tasks involve the immediate serial recall of verbal information including lists of digits or words.

Verbal working memory

These tasks necessitate simultaneously processing and storing of verbal information. For example, counting the number of circles on successive displays of circles and triangles and then recalling the correct number in sequence, at the end of the displays.

Visuo-spatial short-term memory

These tasks involve reproducing sequences in the correct order when presented as dots in a matrix or pointers on blocks.

Visuo-spatial working memory

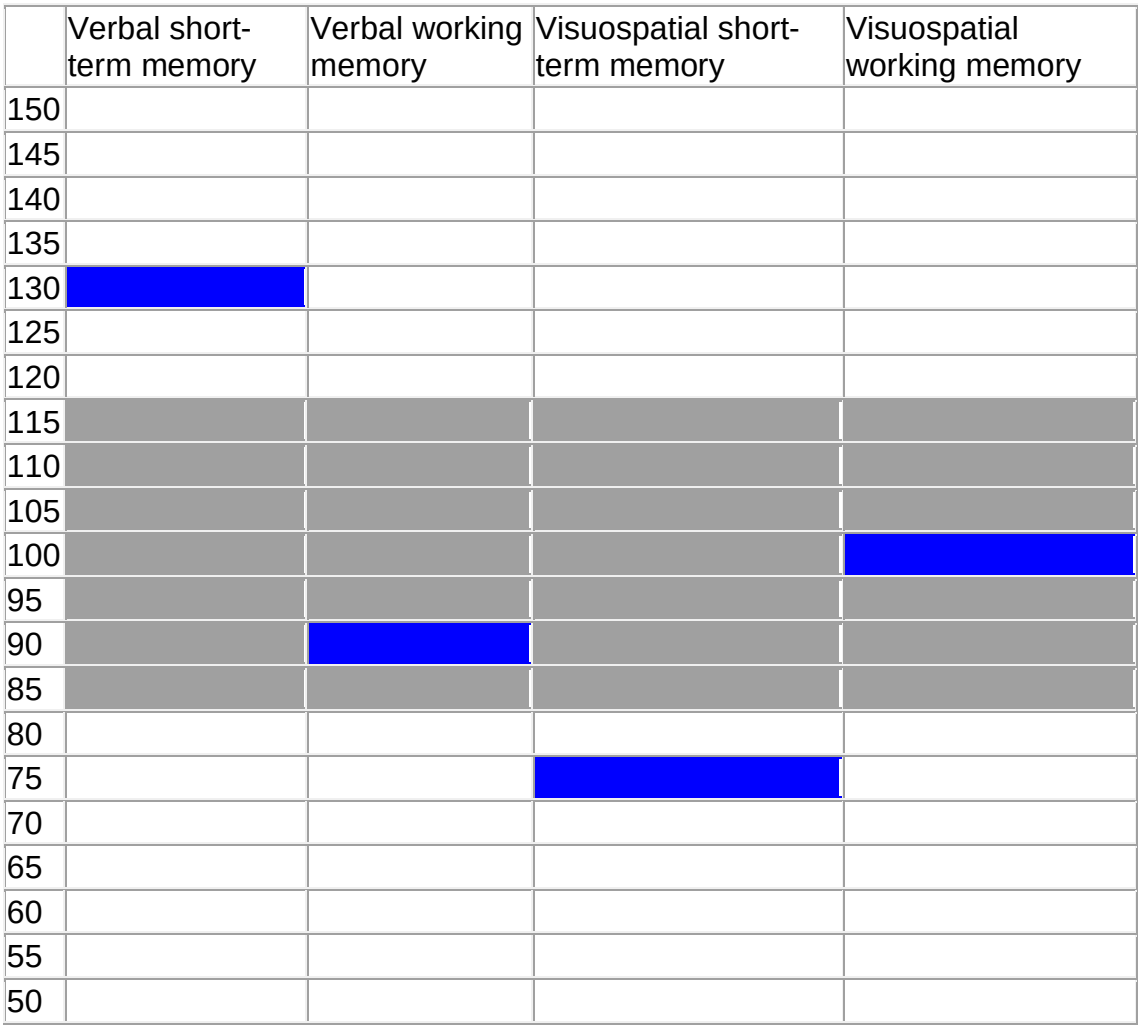
These tasks involve the simultaneous processing and storage of visuo-spatial information. For example, stating whether two shapes are the same or opposite way around to each other and then recalling the position of a red dot shown on one of the shapes.

These scores are based only on the memory scores and do not include the processing scores.

TEST	STANDARD SCORE	PERCENTILES
VERBAL SHORT-TERM MEMORY		
Digit recall	127.0	96.0
Word recall	121.0	92.0
Nonword recall	145.0	99.9
Composite score	131	98
VERBAL WORKING MEMORY		
Listening recall	119.0	90.0
Listening recall processing	121.0	92.0
Counting recall	74.0	4.0
Counting recall processing	77.0	6.0
Backwards digit recall	87.0	19.0
Composite score	91	27
VISUO-SPATIAL SHORT-TERM MEMORY		
Dot matrix	75.0	5.0
Mazes memory	83.0	13.0
Block recall	91.0	27.0
Composite score	78	7
VISUO-SPATIAL WORKING MEMORY		
Odd-one-out	105.0	63.0
Odd-one-out processing	95.0	37.0
Mister X	88.0	21.0
Mister X processing	92.0	30.0
Spatial recall	109.0	73.0
Spatial recall processing	96.0	40.0
Composite score	101	53

Standard scores and percentiles

Scores are standardised to a mean of 100 and a standard deviation of 15 for each age band. Percentiles represent the percentage of individuals in the same age band who obtained this score or less. Composite scores provide a broader description of an individual's working memory: The standard scores of the subtests in each memory component are summed and then standardised. These scores are based only on the memory scores and do not include the processing scores.



Graph: Composite Memory Scores

This graph indicates whether Bob is at risk for working memory problems. The grey shaded area represents average or typical performance for this age group. The blue area represents Bob's working memory profile.

Appendix Two: Transcript and commentary of pattern awareness session (week 1 and week 2)

Researcher: “Bob, we are going to do two jobs today. First of all, I’m going to give you some different things to explore and I want you to make some patterns for me.”

Bob: “OK”

Researcher places a variety of objects on the table in front of Bob. Bob observes then reaches to grasp a clothes peg with his left hand using all fingers and thumb. He is sat in an upright position, eyes looking down at his hand. His right-hand is raised slightly above the surface of the table and his fingers are outstretched. He lifts the peg to chest level in front of his body and holds it with both hands. He makes a comment to the researcher (not audible) whilst squeezing the peg with his left hand and putting a finger on his right hand inside the peg. Researcher continues to put objects on the table.

Researcher: “You are pegging your fingers are you?”

Bob smiles, lowers hands and repositions the peg onto his finger saying, “Ow!” He reaches for another peg using his left hand, whilst his head is still tilted back. He releases the peg on the table, moves his head further back and unpegs his finger. Researcher places more objects on the table and Bob brings his head forwards to look at the objects. He is still holding the peg. He squeezes the peg with his left hand, looks down at his hands and attempts to put the peg on his thumb. Researcher speaks to Bob (not audible, but referring to the objects placed on the table). Bob transfers the peg to right-hand and reaches towards the Numicon pegs with his left hand. During this action he is looking towards the researcher. Bob transfers clothes peg and Numicon peg to right hand then transfers the clothes peg back to his left hand. Holding the Numicon peg with his right hand, he tilts his head forward to observe his actions as he attempts to clip the clothes peg onto the Numicon peg. Researcher tells Bob that the peg board is on the table if he wants to make some patterns using the Numicon pegs. Whilst saying this researcher puts a peg onto the peg board and Bob observes. Bob looks towards the peg board then reaches out with his left hand and tries to clip the clothes peg onto the peg on the peg board. He observes his actions. He then moves the clothes peg back towards his body, points to

the finger on his right hand, and tries to clip the peg back onto it. He observes his actions. He moves his body backwards and says, “Ow!”
Researcher: “Be careful you don’t hurt yourself doing that.”
Bob leans forwards, lowers both hands to the table and looks at the peg and his hands briefly. He is distracted by a noise and looks up.
Bob has six clothes pegs on the table. His head is leaning forwards whilst looking down at his hands. Right hand is on the table top with fingers slightly open, left hand is grasping a peg with fingers and thumb. Bob clips a clothes peg onto his thumb (right hand), leans backwards and says, “Ow!” He then releases his thumb and clips the peg onto his finger (right hand). Bob has clipped a clothes peg onto a finger on his right hand. He continues to hold the peg with his left hand he tilts his head backwards and says, “Ow!” He then releases the peg, puts it on the table and slumps his body forwards.
Researcher: “What little job are you doing for me Bob?”
Bob does not respond but leans forwards to take another peg with his left hand.
Researcher: “Do you know what you’ve got to do?”
Bob does not respond and continues with his action (taking a rod out of the box). Bob takes a yellow rod out of the box and brings it to where the pegs are in front of him, on the table. He attempts to position the rod on top of a clothes peg. The thumb of his right hand touches the rod which he is holding with his left hand using thumb and fingers. Bob sits upright and raises his hands above the top of the table, the clothes peg is squeezed using his left hand, the rod is held with his right hand near to the clothes peg. His head is tilted forwards and he observes his actions. He attempts to clip the clothes peg onto the rod. He attempts this several times unsuccessfully, lowers his hands and puts the clothes peg onto the table. Bob picks up the clothes peg with his left hand, raises the rod with his right hand, leans slightly towards his right side, and attempts to clip the peg onto the rod. He is successful, lowers his right hand to rest on the table top, and raises his left hand whilst holding peg at eye level to look at it briefly. Bob lowers his left hand then takes hold of the peg with his right hand too. The clothes peg snaps and the yellow rod falls onto the table.
Researcher: “Oops!”
Bob makes a grunting noise as he looks down at the broken peg.
Researcher: “Has it snapped off?”

Bob makes another noise and says he will use a different peg.

Bob: “That is broken.”

Researcher: “What job did I ask you to do?”

Bob picks up another clothes peg with his left hand, looks towards researcher and says, “I’m not sure.”

Researcher: “You were going to make some patterns for me. Can you make some patterns?”

Bob picks up another clothes peg with his right hand and attempts to clip the peg in his left hand onto it. He leans forwards and observes his actions. He makes noises to himself whilst doing this. He then sits up, puts the peg onto the table with his left hand and picks up a different clothes peg. He says, “It’s broke!”

Researcher: “Don’t worry we can throw it away later.”

Bob picks up a clothes peg with his left hand and transfers it to his right hand; he picks up the rod with his left hand and brings both hands together. He tilts his head forwards to observe his actions. He says, “I’m going to use a yellow peg.” He leans forwards whilst looking down at his hands to look at the clothes peg in his right hand. He makes comments about it (not audible). Bob holds the clothes peg in an upright position, on table top, with both hands then transfers it to his right hand, as he moves his left hand to pick up the rod and move it towards his right hand. He leans forwards with his head tilted down towards his hands whilst observing his actions. He attempts to clip the rod onto the clothes peg but it is unsuccessful and the rod slides across the table. He picks up the rod up with his left hand and attempts to push it into the clothes peg.

Bob: “Push!”

He sits upright, raises his left hand which is still holding the peg, and reaches towards the rod with his right hand. He then puts the clothes peg onto the table while still holding it out using fingers and thumb. He lifts the clothes peg up to chest level, tilts his elbow towards the ceiling, raises his right hand, holding the rod and attempts to clip peg onto the rod. This is unsuccessful but he attempts it again. It is unsuccessful so he positions both hands onto the table, looks towards the researcher and sits upright. He speaks to the researcher (not audible). Researcher puts some coloured pens onto the table in front of Bob

and says, “They are nice and colourful!” Bob picks up a yellow pen with his left hand and holds the end of it with his right hand. He flips the pen over so that the opposite end is in his right hand and the lid is in his left hand. Researcher shows Bob a piece of paper which has pictures of blank T-shirts on them. She explains that he can colour patterns onto them. Bob puts the yellow pen back onto the table and picks up the green pen with his left hand. Bob attempts to pull the lid off with his right hand, as he tilts his head backwards. He makes a comment about the pen as he attempts to take the lid off again, using his left hand. He is sat upright head facing towards his left and making a grimacing face. Bob makes a comment about the pen (not audible).

Researcher: “Do you want some help?”

Researcher takes end of the pen and helps Bob pull the lid off.

Researcher: “Are you going to draw some patterns Bob?”

Bob leans towards his left side and with the green pen in his left hand, makes marks on the paper. He randomly colours parts of the T-shirt, then tap the pen on the paper repetitively to make marks and dots. (No pattern evident).

Researcher: “Are you drawing a pattern for me?”

Bob does not respond but continues to make marks on the paper. Bob takes the pink pen, attempts to take lid off independently, but fails and puts the pen back down on the table. He picks up the green pen with his left hand and takes the lid with his right hand and pushes it on.

Researcher: “You can leave the lid off until you’ve finished, if that’s easier. Tell me when you’ve finished your pattern.”

Bob picks up yellow pen and attempts to take the lid off independently but unsuccessfully. He looks towards researcher and she helps to take lid off. Bob makes some yellow marks on top of the green marks.

Pattern awareness week 2

Researcher gives Bob a piece of paper with two T-shirts drawn on it, and a blue and green colouring pencil.

Researcher: “Bob, can you start off by drawing a pattern for me on the T-shirts with those two colours?”

Bob takes the blue pencil with his left hand, and stabilises the paper with his right hand. He draws a line on the T-shirt then looks up.

Researcher: “Drawing a pattern for me Bob?”

Bob picks up the green pencil and makes small marks on the second T-shirt. He is distracted by noise in the workspace and looks up. Bob looks down at his paper and continues to make marks with his green pencil. He looks towards his right side, as a teacher walks through the space. He puts his green pencil on the table, and picks up his blue pencil. He makes marks on the T-shirt consisting of lines and squiggles. Bob looks up and scans the environment briefly, then picks up the green pencil and makes more marks on the paper consisting of lines. Bob looks up.

Researcher: “Tell me when you finished won’t you?” Bob continues making marks on the T-shirt using his green pencil. Bob looks up and makes a comment (not audible).

Researcher: “Say that again Bob.” Bob repeats comment (not audible). He continues to make marks on the paper with the green pencil. Bob looks towards his right as adults enter the workspace and pass a comment to each other. Bob scans the space then continues to make marks on his paper with the green pencil. Bob drops the green pencil on the table, picks up the blue pencil, and looks up.

Researcher: “Have you finished that job Bob?”

Bob puts the blue pencil onto the table and folds his piece of paper, making a crease down the middle.

Researcher: “Don’t fold it I’m going to put it in the plastic wallet.”

Researcher places coloured unifix on the table and says, “You need to tell me which one?” (Strip of alternative yellow/orange unifix cubes and two other strips of random colours).

Bob takes the first strip that was placed on the table, and pulls it into two.

Researcher intervenes to put them together again and says, “Leave them

altogether Bob, you can pull them apart in a minute." Researcher repositions the three strips in front of Bob, flat on the table, and says, "Out of these three which ones are patterns? Bob taps each strip in turn then picks up the strip of alternative yellow and orange unifix.

Bob: "All of them."

Researcher: "All of them are patterns? Why are they patterns? Can you explain to me why they are patterns?"

Bob pulls parts of the alternative orange and yellow block apart and says, "Because they can be."

Researcher asks for clarification, "Because they are mixed? What was the last little bit you said?"

Bob continues playing with the unifix and says, "Because they are mixed with colours."

Researcher repeats back what he said. Researcher takes the three strips away and says, "Can you show me which ones of these are patterns Bob?"

Researcher positions four strips in front of Bob flat on the table. (One purple strip, one brown strip, one strip comprising consecutive blacks with two yellows at the bottom, and a strip comprising of alternative blue, white and green and a fifth strip comprising three orange, two yellow, two red and two black).

Researcher: "Which ones are patterns?"

Bob takes the strip of alternative blue, white and green and pulls a green piece from the end.

Researcher: "Which ones are patterns? You tell me which ones are patterns."

Bob picks up strip and pushes the green block back on. Researcher moves the strips further towards Bob and says, "Can you show me?" Bob makes a noise and continues with what he was doing.

Researcher: "Which ones are patterns Bob?"

Bob does not respond and continues with his own activity. He is distracted by children and adults coming in and out of the space. Bob puts the strip back onto the table. Researcher picks it up and positions is next to the other strips.

Researcher: "If we look at them (pointing to the different strips) which ones are patterns?"

Bob does a karate chop hand movement on top of the two end strips. He then pulls a strip of purple unifix towards his chest, on the table top. Researcher taps the strip and says, “Is this one a pattern?”
Bob: “It’s all the same colours.”
Researcher removes the strip so it is out of reach and puts the next strip in front of Bob (blue, green, white). Researcher holds it up in front of Bob and says, “Is this a pattern?” Bob looks at it and reaches to touch it.
Researcher: “What do you notice about it?”
Bob looks towards his right side, distracted by noise coming from their nearby classroom.
Researcher: “What can you tell me about this one Bob?”
Bob continues to look inside the nearby classroom for a few seconds, then looks at the strip and reaches to touch it with his left hand.
Researcher: “What can you tell me about this one Bob?”
Bob points to the bottom green block and says, “Green” before being distracted by the classroom noise.
Researcher: “Yes, well done. Green, green...”
Bob looks back at strip holding it with the researcher. He points to some of the blocks and states what colours they are in sequence.
Bob: “Green, white, blue.”
Researcher: “What do you notice about that then?”
Bob: “They are all different colours.”
Researcher: “Okay!”
Researcher puts the strip out of Bobs’ reach. Researcher takes the next strip (black and yellow in blocks of colour but not in a pattern). Researcher holds it up and says, “Is it a pattern?” Bob looks at it then it takes the strip from the researcher with his left hand. He transfers this to his right hand briefly then holds it with both hands. He looks up as he is distracted by noise in the workspace. Researcher points to the strip and says, “Is this one a pattern Bob?” Bob briefly looks at it, then up again, and towards the researcher, then at the black part of the strip. He pulls the bottom yellow part away, using his right hand. Researcher intervenes and takes the strip saying, “Pop them together a minute, you can have a little play with them in a minute Bob.” Researcher takes

the strip from Bob and puts the two parts back together again. Bob observes.
Researcher holds it up and says, “Is this one a pattern?”
Bob touches the strip and says, “No.”
Researcher: “No? why not?”
Bob points to the different blocks in sequence and says, “Yellow, then yellow, yellow, and black, then black, then black and black, then black.”
Researcher puts the strip down onto the table and says, “Okay.” Researcher takes a strip comprised of all brown and says “What about this one, is this a pattern?” Bob looks at the strip, he is distracted for a second, then he looks at the strip, and points to the blocks in sequence, saying, “black, black, black, black, black.”
Researcher: “Is it a pattern?”
Bob: “No.”
Researcher puts that strip with the others and presents the next one to Bob (orange, red and brown in blocks of colour but not in a pattern).
Researcher: “What about this one, is that a pattern?”
Bob looks at it, is briefly distracted by the pupils in the workspace.
Researcher: “Is this one a pattern Bob?”
Bob continues to remain distracted briefly then looks at the strip and points to it.
Researcher: “Is this one a pattern?”
Bob points to the blocks in sequence and names the colours. He is distracted again and prompted by the researcher, “Orange…” Bob looks back at the strip and continues to name colours in sequence. He is distracted again and prompted by the researcher, “Brown…” Bob points to the last three blocks and says, “Brown, brown, brown.”
Researcher: “Is it a pattern?”
Bob smiles, “Yes!”
Researcher: “You think it is a pattern? Why do you think it’s a pattern?”
Bob reaches towards the strip with his right hand and says, “Because they are all different colours.”
Researcher: “Because they are all different colours!”
Researcher puts the strip on the table.
Researcher: “They are all different colours?”

Bob is distracted and looks away. Researcher takes a bag of coloured unifix cubes and says, “I thought you would like to make me a pattern Bob! Can you make me a little pattern?”
Researcher takes the cubes out of the bag and says, “Can you make me a pattern Bob?” Bob takes a pink and red cube and tries to push them together using both hands. He is unsuccessful and looks towards the researcher.
Researcher: “Do you know what a pattern looks like?”
Bob picks up the red and pink cubes with both hands and attempts to push them together. He is successful, and holds the strip of cubes in his right hand as he reaches to pick up a green cube with his left hand. He pushes this on top of the red cube. He then reaches to pick up a pink cube with his left hand and pushes this on top of the green cube. He transfers the strip of four cubes into his left hand, as he looks up at the other pupils using the workspace.
Researcher: “What comes next in your pattern Bob?”
Bob transfers it straight back to his right hand and reaches with his left hand to pick up a red cube, and put it on top of the strip. He is distracted again.
Researcher: “What comes next Bob?”
Bob picks up an orange cube with his left hand and puts it on top of his strip. The existing red cube falls off and Bob re-attaches it and looks up. He looks back down at his strip and pushes the orange cube at the end of it.
Researcher: “Can you tell me about your pattern Bob?”
Bob continues pushing the orange cube on and says without looking up, “It’s not ready yet.”
Bob takes the bottom pink cube from the strip as he looks around the workspace. He turns the strip around in his right hand so it is facing the other way (top at bottom). He attempts to push the pink cube on top of the red cube unsuccessfully. One of the cubes falls onto his lap. Bob makes a sound, “Dah!” He picks it up using his left hand.
Researcher: “Do you want some help?”
Bob rotates strip through 180 degrees in his right hand so it is facing the other way and attempts to put an orange cube on top of the red one, this time successfully.

Appendix Three: Intervention session week one

To begin to see patterns in number relationships

Ordering Numicon shapes

- Put Numicon shapes in order. Ask which shapes to start with. When in order, ask what pupil notices. (e.g. alternating odd/even pattern, increasing or staircase pattern).
- Ask if a different shape could be used to start the pattern. (If biggest, does pupil notice a decreasing pattern?)
- Compare the two ordered rows (increasing/decreasing). Encourage conversation about how one pattern goes up and one goes down.

Exploring ordering with Numicon shapes

- Show pupil a selection of shapes. Ask pupil to arrange them in order of size. Agree that any group of objects can be placed in size order.
- Arrange one set of shapes randomly, and another set in order, 1-10. Ask what pupil notices. (pattern when shapes are ordered).

To begin to recognise that patterns follow rules

Labelling Numicon shapes with Numicon

- Ask pupil to put the shapes in order, starting with the smallest. Starting with the 1-card, show pupil the numeral cards one by one and ask suggest which shapes the numeral card should go with.

Matching Numicon shapes and Numicon shapes patterns

- Ask pupil to put a set of 1-10 shapes in order. Using pegs and a baseboard, build a Numicon shape pattern. Ask pupil to hold up the shapes that matched the Numicon shape pattern you built and to tell you the name of the Numicon shapes and the Numicon shapes pattern.
- Repeat for different shapes.

Appendix Four: Examples of completed recording sheets

4a) Typography of movement observation

1. Typo-graphy of movement	**ACTIVITY:** assessment of free activity: undirected play							**CONTEXT:** Quite workspace outside two adjoining classrooms			
Time span observed: first minute			Observer: LC					Week one			Sheet 1
Time-frame (seconds)	**0-5**	**6-10**	**11-15**	**16-20**	**21-25**	**26-30**	**31-35**	**36-40**	**41-45**	**46-50**	**51-55**	**56-60**
Environmental Factors	Quiet (Q) Noisy (N) Pupils walking through space (P) Adults walking through space (A)											
	Q	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**
Head Movements	Head movements prevent child from looking at what he's doing											
	Control of head movements enables child to co-ordinate hands and eyes											
	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Postural Control	Upper body position enables hand-eye co-ordination: yes ✓ no ×											
	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Upper body position for this purpose sustained: yes ✓ no ×											
	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Control Of Arms	Controls movement of arms for task where needed right hand (R) left hand (L) both hands (B)											
	B	**B**	**B**	**B**	**B**	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Control Of Hands	Controls movement of hands for task right hand (R) left hand (L) both hands (B)											
	B	**B**	**B**	**B**	**B**	**B**	**B**	**B**	**B**	**B**	**B**	**B**
Use Of Hands	Reaches for objects: right hand (R) left hand (L) both hands (B)											
	L		**L**	**L**		**L**	**L**		**L**			
	Grasps objects: right hand (R) left hand (L) both hands (B)											
	L		**L**	**L**		**L**	**L**	**L**	**L**	**L**		
	Manipulates objects: right hand (R) left hand (L) both hands (B)											
	B		**L**	**L**	**B**		**L**	**L**		**L**		**L**
	Stabilizes object with one hand and manipulates with the other hand											
	Rotates and examines objects											
	✓		✓	✓	✓		✓	✓	✓	✓		✓
	Twists/turns/stacks/releases objects: TW / T / S / R											
			T		**T**		**T**	**T**		**S**		
	Pushes objects together / pulls objects apart: PT / PA											
	PT		**PT**		**PT**		**PT**	**PT**		**PT**		
Use Of Fingers	Can grasp and hold objects with all fingers acting together: right hand (R) left hand (L) both hands (B)											
	L		**L**	**L**	**L**		**L**	**L**		**L**		
	Picks up small objects using finger and thumb: right hand (R) left hand (L)											
	L		**L**	**L**		**L**	**L**		**L**			
	Uses thumb in grasping objects: right hand (R) left hand (L)											
	L	**-**	**L**	**L**	**L**	**L**	**L**	**L**		**L**		
Hand-Eye Coordination	Visual alertness and attention to relevant features of the task											
	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Attention to hand carrying out task when necessary											
	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Visually directed grasping											
	✓		X	X		X	X					
	Reaches for object when both hand and object are in view											
						X	X					
	Grasps when just object is in view											
				✓								

4 b) Completed intervention recording sheet

2. Intervention recording schedule: T1 (Pattern 5 video recording)

Observer: Researcher	Sheet 1 of 2	Context: Bob is seated in wheelchair which is too low for the height of the table. Working in a small room. Piano being tuned in the hall, which is audible and causes distractions.

Time frame on video	See coding sheet • On-task = Y • Off-task = x • Behaviours affecting focus = F • Interruptions affecting focus = I • Other = Z

0-59 Secs	Starting point for T-1		11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
1.0 – 1.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
	X(g)	X(g)	X(g)	I(N)	I(N)	I(N)	I(N)	Y	Y	Y	Y	Y
2.0-2.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
	Y	I(N)	I(N)	X(j)	Y	Y	I(N)	I(N)	I(N)	X(a)	Y	X(c)
3.0-3.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
	X(c)	X(c)	X(c)	X(c)	X(c)	X(c)	Task ended by researcher		Resources for T-2organised			Y
4.0-4.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5.0-5.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
	Y	Y	Y	Y	T-3	Y	Y	Y	Y	I(N)	Y	Y
6.0-6.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
	Y	Y	Y	Y	T-4	Y	Y	Y	Y	Y	Y	Y
7.0-7.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
	Y	Y	F(B)	F(B)	X(j)	Y	Y	Y	Y	Y	Y	Y
8.0-8.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
	X(c)	X(c)	X(j)	Researcher makes new pattern					Y	Y	X(a)	Y
9.0-9.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
	Y	Y	Y	Y	Y	Y	I(N)	I(N)	Y	Y	X(d)	X(d)
10.0-10.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
	X(j)	T-5	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
11.0-11.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
	Y	Y	X(c)	Y	T-6		Y	Y	X(h)	Y	Y	Y
12.0-12.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
	Y	Y	Y	Y	Y	Y	Y(E)	Y(E)	Y(E)	Y(E)	Y	Y
13.0-13.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60
	Y	Y	X(g)	X(g)	Y	Y	Y(E)	Y(E)	Y(E)	Y(E)	Y(E)	F(B)
14.0-14.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
	F(B)	X(d)	X(g)	X(c)	X(c)	X(d)	X(d)	X(d)	Y	Y	Y	Y
15.0-15.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
	Y	Y(E)	X(d)	X(d)	X(d)	F(B)	X(d)	X(d)	X(d)	X(d)	X(d)	X(d)
16.0-16.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60
	X(j)	Y	Y	Y	X(j)	X(j)	X(g)	X(c)	X(c)	X(c)	X(c)	X(c)
17.0-17.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
	X(c)	X(c)	X(c)	X(c)	X(c)	I(N)	T-7		Y	Y	Y	Y
18.0-18.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	X(d)	X(d)
19.0-19.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
	X(d)	X(d)	Y	F(B)	Y	Y	Y	Y	Y	Y	Y	Y

4 c) Completed recording sheet: Prompts

Recording sheet for prompts: Pattern awareness 5 Baseline Assessment T1												
Observer: Researcher					Sheet 1 of 2							
Time frame on video	Record of prompts to support on-task behaviour											
0-59 Secs	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
1.0 – 1.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
					P	P						
2.0-2.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
			P									
3.0-3.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
4.0-4.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
		P		P		P					P	
5.0-5.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
	P											
6.0-6.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
				P	P							
7.0-7.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
				P	P					P		
8.0-8.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
9.0-9.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
10.0-10.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
11.0-11.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
12.0-12.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
13.0-13.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60
14.0-14.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
15.0-15.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
16.0-16.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60
			P	P	P					P		P
17.0-17.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
					P						P	
18.0-18.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59
	P											
19.0-19.59 mins	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-59

4 d) Section of completed recording sheet: coding of raw T1 data

3. Sequences of actions observed during T-1

Time frame on video Seconds-minutes	Looking at object, Researcher or Teaching Assistant		Handling Pointing at or Reaching Towards	Speaking or making sound effects (Vocals)	Hand used L R B	Location FR R FL L F	On Task YES/ NO	Notes	Sequence
Investigation-1 1 Task-1									
0-10				Speak		FR	YES		1
11-21	O	RES				R			Speaking
			R-T		LH	FR			Looking
22-32			P-A	Speak	LH	R			Handling
			H		LH	FR			Speaking
	O					FL			Handling
	O		P-A		LH	FL			Looking
		RES		Speak		R			Speaking
33-43	O	RES				FR			Looking
		RES							Handling
				Speak					Speaking
	O	RES		Speak		FR			Handling
		RES		Speak		F			Looking
			H	Speak					Handling
									Looking
44-54	O		H		LH	FL	NO	Off-task at 50 seconds	2
	O	RES				R			Looking
	O		R-T	Speak	LH	FR			Handling
	O		H		LH	R			Looking
	O		P-A		LH	F			Handling
	O		P-A	V	LH	L			Speaking
	O		P-A		LH	L			Looking
	O		P-A		LH	FL			Handling
									Looking
55-65	O		P-A		LH	FR			Handling
	O		P-A						Looking
				V					Handling
			P-A		LH	R			
					LH				
	O		H		RH	R			
			H	V	RH - LH	R-L			
1.06 – 1.16	O								
			H		LH	R-L			
	O					R			
			H		RH	R			
		RES				L			
		RES				L			

Appendix Five: Timetable for the Study

Autumn 2015 – Spring 2016		
Phase	**Dates**	**Purpose**
T1	Autumn term 2015	Assessment of understanding Five video recorded assessment sessions to ascertain pupils' understanding of 'pattern' using a series of practical activities. Typography of movement assessment. Five video recorded sessions of pupil undertaking undirected exploration using practical resources.
Intervention phase 1	18th Jan, 25th Jan, 1st Feb, 8th Feb	Taught activities to develop understanding of pattern using practical resources
Withdrawal period 1	15th Feb, 22nd Feb	Withdrawal period to assess effectiveness of intervention
T2	29th Feb	Activities presented in T1 repeated and measured against criteria
Intervention phase 2	7th March, 15th March, 21st March, 29th March	Taught activities to develop understanding of pattern using practical resources
Withdrawal period 2	4th April, 11th April	Withdrawal period to assess effectiveness of intervention
T3	18th April	Activities presented in T1 repeated and measured against criteria
Intervention phase 3	25th April, 3rd May, 9th May,16th May	Taught activities to develop understanding of pattern using practical resources
Withdrawal period 3	23rd May, 30th May	Withdrawal period to assess effectiveness of intervention
P1	6th June	Activities presented in T1, T2 and T3 repeated and measured against criteria
Withdrawal period 4	13th June – 4th July	Four week withdrawal period to assess longer term effectiveness of intervention
P2	11th July	Activities presented in T1,T2 and T3 repeated and measured against criteria

Appendix Six: T1 Transcript and commentary of the assessment

Bob takes two pegs out of peg bag using left hand. He pushes one onto the first finger of his right hand. He is seated in an upright position and observes his actions. He pushes the second peg onto his thumb.

Researcher places the peg board on the table in front of Bob and says, “Here’s the peg board in case you want to use that, and here are the shapes Bob in case you want to use the shapes.” Bob observes as researcher puts more equipment out. Researcher pushes peg bag closer towards Bob and asks, “Do you want anything else?” Bob does not respond but takes more pegs out of the peg bag and puts them onto the fingers of his right hand. He observes his actions. While looking at his right hand, he puts his left hand into the peg bag, takes a peg out and looks at it. The fingers on his right hand spread out and he looks at the three pegs on two of his fingers and thumb. He puts the fourth peg onto the next finger. He looks up at the teaching assistant and says, “I am making a finger pattern.” He then takes a fifth peg out of the peg bag and positions it on his little finger.

Whilst doing this the researcher places a coloured overlay onto the peg board and says, “I’ll put that on there today Bob so that you have a coloured pegboard.”

Bob looks at researcher and says, “A finger pattern!” He raises his right hand with the fingers outstretched to show the researcher.

Researcher: “Have you made a finger pattern?”

Bob lowers his hand to the table top, looks at his outstretched fingers, and puts his left hand into the peg bag. He takes out a sixth peg and puts it on top of another peg, on his middle finger. Bob raises his hand as the peg falls off. He lowers his right hand to the table with outstretched fingers, touches his thumb with his left hand, looks down and says, “Oh!” as a peg falls onto the floor.

Researcher: “Take another one out the bag, Bob, and I will pick that one up later.”

Bob looks down at his hands as he pulls the peg further up his finger, using his left hand. He pulls his finger backwards and says, “I can’t get it off.” He releases the finger and touches the peg on his little finger, as he observes his actions. He then pulls the peg off the second finger and places it on top of the

peg on his middle finger. He then pulls the peg off his thumb and whilst doing this the second peg on his middle finger falls off. He tries to put the peg he's holding in his left hand onto his middle finger but it drops onto the table. He looks towards the box of shapes, positions his right hand onto the table with outstretched fingers, and takes three nine shapes out of the box, using his left hand. He leans forwards and drops the nine shapes onto the peg board whilst observing his actions. Bob reaches to the box of shapes and pushes his thumb and two fingers through three separate piles of shapes, adjacent to each other in the box. He leans forwards to observe his actions. He moves his hand so that it is above the pegboard, lifts his hand up slightly as he makes a comment (not audible). As he moves his fingers, some of the shapes fall off onto the peg board. He looks towards the right, and releases the rest of the shapes onto the peg board. He looks over towards the box of shapes stretches his fingers out and takes two piles of shapes out of it. (Five ten shapes and four five shapes). He drops them onto the peg board and puts a ten shape back on to the box of shapes. He takes a three shape out box using his left hand and drops it onto the peg board, as he hums to himself. He briefly looks away from the equipment then looks over at the box of shapes as he pushes his thumb and first finger through another pile of ten shapes. He takes them over to the peg board, the bottom ten shape falls off, he releases three shapes, then releases the final shape with a flicking action, onto the peg board. He leans forward, towards the box of shapes then takes another ten shape out of it whilst observing his actions. He takes a further ten shape and moves his hand over towards the peg board. He releases one and puts the other one back into the box of shapes. Bob looks over at the teaching assistant and makes a comment about what he is doing (not fully audible). Whilst making the comment he puts his left hand into the box of shapes and lifts out a pile of five shapes.

Researcher: "What are you making Bob?"

Bob says something about numbers (not audible). Whilst making this comment he moves one of the five shapes from the peg board to the box of shapes. He observes his actions. He makes a comment about a pile (not audible).

Teaching assistant: "That pile, what's that?"

Bob responds (not audible). He leans forwards to observe his actions as he takes more shapes out of the box. He releases all of the shapes except two

and looks at the teaching assistant as she makes a comment to him. Bob looks at her, smiles and moves the shapes he's holding in his left hand to the pegboard. He looks down as he releases all of them except a two shape which is pushed onto his thumb. He takes a pile of four shapes out of the box and releases them onto the peg board. The two shapes remains on his thumb. He looks over at the box of shapes, drops the two shapes into the box then picks it up again using a pincer grip. He moves it over to the pegboard and drops it on top of the pile of other shapes. He looks over at the box of shapes as he takes more shapes out of it and drops them onto the pegboard. As he does this, he looks over at the teaching assistant. He makes a comment to her (not audible). He then looks towards his left, as he puts his left hand into the box of shapes and takes two nine shapes out of it. He releases them on top of the pile of shapes, on the pegboard. Takes a two shape out of the box and flicks it onto the pile. He briefly moves his left hand over to the box of shapes, and back to his right hand, he takes a peg off one of the fingers whilst observing his actions. He drops this peg onto the table and takes another peg off another finger. This drops onto the floor, he looks at it and then at the teaching assistant, and says, "Oh!" He leans backwards, moves his hands apart and looks at the peg bag, as the researcher makes a comment (not audible). He pulls the final peg off his little finger and drops it on the table. He then reaches over to the box of shapes pulls it towards him, and takes out a pile of four shapes. He moves his hands with the shapes above the peg board and releases the bottom shape, then the next shape, third shape that is holding them puts the fourth shape back into the box. He looks over at the pegboard reaches towards a ten shape, and says, "There are no more ten shapes."

Researcher: "You have only got one ten shape left."

Teaching assistant: "You've used them all Bob."

Bob takes the final ten shape out of the box and puts it on top of the pile of shapes on the peg board. He observes his actions. Bob then runs his hand over some of the shapes in the peg board then looks at the box of shapes and reaches over with his left hand. He leans forward to observe his actions. He takes out a pile of three shapes and puts them on top of the pile of shapes. He takes a one shape out of the box using a pincer grip, looks over at the teaching assistant and makes a comment (not audible). He looks down at the shapes

and puts the one shape on top of the pile of four shapes. Bob then picks up the one shape with two four shapes and immediately releases them back onto the pile of shapes on the pegboard. He looks down at his lap and says, “Awh!” He picks up a three shape, on his lap, and puts it onto the table. The researcher puts another three shape into the box of shapes and comments on the action. Bob looks over and takes a four shape out of the box without looking. He drops it onto the pile of shapes and goes back to the box for a three shape. He puts this onto the pile of shapes and takes some more shapes out of the box using a pincer grip, and humming. While looking down at the floor he releases shapes in his hand and takes a peg that was on his lap and puts it back into the peg bag. He looks back down at his lap and takes a four shape from it and puts it back into the box of shapes. He reaches towards the pile of shapes with his left hand, takes a ten shape and drops it into the box, using a flicking action. He picks it up again, leans forwards and positions it into the compartment for the ten shapes, inside the box.

Appendix Seven: P2: Transcript and commentary (first fifteen minutes)

Researcher: “Our first job Bob, I want you to make a pattern for me using all the green ones. So leave them as they are, but make a pattern using all of them.”

Researcher places the unifix cubes in a pile on the table. Bob picks one up and positions it vertically.

Bob: “Can I have a bit of help putting these up?”

Researcher: “Yes!”

Bob positions a short strip adjacent to the first tall strip followed by a tall strip which he holds in his right hand. He then picks up another short strip with his left hand, looks at researcher and asks, “Do we need two small ones?”

Researcher: “You decide how you want the pattern.”

Bob: “Two small ones.”

Bob then positions a tall one which topples over and knocks the short ones over.

Researcher: “Let me pop that one up for you” (intervenes and puts the tall strip in an upright position, followed by the two short ones, in the same arrangement Bob had made.

Researcher: “Right, what’s coming next in your pattern?”

Bob positions a short strip and a tall strip in a vertical position. As he does this the other strips are knocked and researcher repositions them again. Bob positions his hand to knock the strips over.

Researcher: “Don’t knock them over Bob (intervenes to stand them up again.) “Now, I want you to look at the pattern and I want you to see if you can change something so that we’ve got a tall one and a short one.” (Bob reaches to take a short strip.) “A tall one, then a short one.”

Bob pushes the strips together and examines them. Researcher helps to stop them toppling over. Bob moves a short strip into the row. Researcher moves them in to help and asks where the final tall strip will go. Bob puts a short strip next to another short strip. “That’s going to go here.”

Researcher: “Why is it going to go there?

Bob: “Because then we’ve got ….”

Researcher: “Let’s see what we’ve got Bob. (Points to strips in turn) tall, short, tall (Bob joins in) short.” (Researcher points to the final two in turn and pauses).

Bob: “Short, tall.”

Researcher: “So if we want it to….can you remember that word we used, when we’ve got…?”
Bob: “Alternating.”
Researcher: “Alternating! Well done! So can you change it for me Bob? (Bob positions his hand to knock them over but researcher blocks the move). You can knock them over in a minute Bob. So, can you change it for me Bob so all of the pattern is alternating? So we’ve got a tall, a short, a tall, a short. What do you need to change?”
Bob picks up a tall strip and tries to position it on top of a short strip.
Researcher: “What do you need to change Bob?”
Bob sings to himself and moves the last four strips close together.
Researcher: “What needs to change?”
Bob picks up a short strip from the start of the pattern.
Researcher: “What needs to move?”
Bob: “That one.”
Researcher picks up all the strips and moves them from the table. “Right, you tell me what you need. Put that one down first then Bob”
Bob drops the short strip he was holding, then positions it in a vertical position.
Researcher moves it over to start a new pattern.
Researcher: “What do you want next Bob?”
Bob: “A long one.”
Researcher hands Bob a tall strip. “Pop that one up then Bob. Ask if you want some help sticking it up.”
Bob whispers, “Can I have some help?”
Researcher helps to stabilise the strip. “What’s going to come next? We’re alternating.”
Bob: “Short one!” (Bob pushes himself up in his seat and responds in a sing song tone.)
Researcher passes Bob a short one. “Short one.”
Bob positions it and sings, “Then a long one.”
Researcher passes Bob a long one, “Then a long one.” (He positions it in the row.) Then a…?”
Bob: “Short one!” Researcher passes Bob a short one which he positions.
“Then a long one!”

Researcher: “Then a long one!” (Passes Bob the final strip which he positions correctly.) Well done Bob!”

Bob proceeds to knock the row over.

Researcher: “Now you can knock them over!”

Researcher: “We are going to do another alternating pattern using black and white.”

Bob yawns and leans over to his right side. “I’m tired.”

Researcher positions the strips of unifix onto the table in a pile.

Researcher: “An alternating pattern using black and white.”

Bob takes a white strip and positions it vertically. As he reaches to pick up a black strip, he knocks the white strip over. Researcher intervenes to reposition it. “A bit of help. What’s coming next?”

Bob places a black strip next to the white strip, and picks up a white strip without any prompting and positions it. Researcher provides some support to ensure they don’t topple over.

Bob: “Is that standing up?”

Researcher: “Yes, it’s standing up. What’s coming next Bob?”

Bob is distracted and looks at the row. “It’s staying up at the end bit?”

Researcher: “Yes, it’s staying up.”

Bob: “It’s staying up on the end bit – look!” (Bob picks up the strip to show researcher – it’s balanced upside down which has distracted Bob.). Researcher picks it up and turns it round. “Let’s turn it up, there you go. What’s coming next Bob?” (Bob turns the strip over again.) Let’s think about what’s coming after the white one Bob. What’s coming next? We’ve got white, black, white.”

Bob puts a white one at the end of the row.

Researcher: “Alternating!”

Bob reaches for a black strip and breaks it into two. He puts half at the end of the row.

Researcher: “Leave them the same length Bob, just alternating the colours, not the sizes.” (Intervenes and moves the strips out of reach. Repositions the strips as Bob watches). So, we’ve got white, black, white, now alternating, what do we want next?”

Bob scratches and rubs his nose then looks over, “Black!”

Researcher puts a black strip on the table horizontally for Bob to position.

Researcher: “What next?”

As Bob releases the white strip the row topples over. Researcher intervenes and puts them back as they were. “What next Bob?”

Bob: “It toppled!” Bob reaches to get the last white strip which he positions at the end of the row.

Researcher: “And last one?”

Bob picks up the last black strip and positions it upside down at the end of the row. It topples over and he positions it the right way up.

Researcher: “Tell me about the pattern then Bob, before you knock it over.”

Bob has positioned his hand ready to knock the strips down.

Bob: “White, black, white, black, white, black.”

Researcher: “Well done! (Bob knocks the row over.) So we’ve got an alternating pattern in black and white, well done!”

Researcher: “Now I want you tell me which two match Bob.”

Bob positions two of the strips in a vertical position and looks at them. “Those two?”

Researcher: “Why do they match Bob?”

Bob: “No, they can’t do.” He pulls them towards himself and looks at the third.

Researcher: “Which two match then?”

Bob: “This one’s got two blacks and that one hasn’t, so...”

Researcher: “Right!”

Bob: “It doesn’t match.”

Researcher: “Well done. So which two match then?”

Bob put the strips on the table and picks up the other.

Bob: “I don’t know.”

Researcher points to the strip Bob is examining. “Which one matches that one Bob?”

Bob picks up the matching strip and examines it.

Researcher: “Have a good look.” Bob positions it vertically in the table and releases it. “Are they the same?”

Bob puts the matching strip next to it. “Yes.”

Researcher: “Yes they are, well done! Right, why do they match Bob? Can you explain it to me? Why do they match?”

Bob: “Because they are all the same colours.”

Researcher: “They are all the same. (Points to each cube) a pink, a brown, a pink, a brown, a pink, a brown, a pink, a brown!”

Bob observes.

Researcher: “What sort of pattern is it?”

Bob: “A pink, a brown (points to each cube) pink, brown, pink, brown.”

Researcher: “Well done! What sort of pattern is it that Bob?”

Bob: “Pink, brown, pink, brown.”

Researcher: “What sort of pattern is it?”

Bob tries to knock the strips over but researcher stops him.

Researcher repeats: “What sort of pattern is it Bob?”

Bob reaches to take the third strip.

Researcher: “What is that word again?”

Bob: (sings) “Alternating!”

Researcher: “Alternating! Well done Bob. Right, knock them over then!”

Researcher: “Right, this time I’m going to start a pattern off and I want you to continue it. I want the pattern to be the same as mine. So I’m going to start my pattern off with a red.” (Puts a red shape on the table).

Bob: “So, I’m going to start my pattern off with a red!”

Researcher: “Then I’m going to have a yellow, then I’m going to have a red, and then I’m going to have a yellow. So we’ve repeated what I’ve started. We’ve got red, yellow, and I’ve repeated it, so I’ve got red, yellow, and we’ve got an alternating pattern…red, yellow, red, yellow!”

Bob turns the first red shape through 360 degrees.

Researcher: “Now I want you to repeat that pattern for me Bob.”

Researcher places the box of shapes on the table near Bob. He pulls it towards him and looks inside.

Researcher: “So you are copying what I have started.”

Bob positions a red shape at the end of the row.

Researcher: “Well done, what’s coming next?”

Bob takes a yellow shape and adds it to the pattern.

Researcher: “Well done! Repeat it again Bob.”

Bob puts a red shape at the end of the row.

Researcher: “Well done!”

Bob takes a yellow shape out of the box and adds it to the pattern.

Researcher: “Wow! Well done Bob, that’s brilliant”

Researcher slides the shapes away.

Researcher: “Right, I’m going to make it a little bit trickier for you. So this time I’m going to have a red, a yellow, a purple (positions them in a row) then I’m going to repeat that, so I’m having a red, a yellow, and purple. Now, I want you to carry on that pattern Bob, so it’s exactly the same as mine.”

Researcher puts the box of shapes next to Bob. “There you go.” Without prompting Bob takes a red shape out of the box and positions it at the end of the row.

Researcher: “Red.”

Bob takes a purple shape out of the box and whispers to himself, “Purple” (He puts it back into the box). No, I forgot that colour.” He exchanges it for a yellow shape and puts it at the end of the row.

Researcher: “Well done Bob, brilliant!”

Without prompting Bob positions a purple shape at the end of the row.

Researcher: “Could you repeat it once more for me?”

Bob looks at researcher but is momentarily distracted as teaching assistant moves the box of shapes.

Researcher: (Regains attention) “Can you repeat it once more for me Bob? So we’ve got (pointing) red, yellow, purple, (Bob joins in) red, yellow, purple… this is your bit (pointing to the last three shapes), can you repeat it once more for me?”

Bob: “OK”

Bob looks inside the box and then starts to collapse the row using his left hand.

Researcher intervenes to stop him. “What’s going to come next Bob? Let’s finish it first.”

Teaching assistant: “Carry it on.”

Researcher: “What’s coming next?”

Bob takes a purple shape out of the box and shows researcher. Researcher points to the shapes in turn, “Red, yellow, purple…”

Bob drops the purple shape on the table. “That’s another one.”

Researcher moves the row along slightly, “Red, yellow, purple…”

Teaching assistant readjusts the last three shapes in the row, to line them up.

Researcher: “Red, yellow, purple, red, yellow, purple (Bob moves the second purple shape at the end of the row.) What’s coming next Bob?”
Bob: (whispers) “Purple.”
Researcher: “Remember we are repeating our pattern. (pointing to start of pattern) So we are going to start off with a ….”
Bob: “Red”
Researcher slides last purple shape out of the row. “Let’s take that one out of the way. Can you put a red one for me? ”
Bob takes a wooden coloured shape out of the box and holds it up before putting it on the table. “There’s the other one.”
Researcher: (Passes Bob a red shape) “There’s a red one Bob.” (moves wooden box of shapes out of reach). “Put your red one out.”
Bob slides the red shape to the end of the row and picks up a purple shape.
Researcher: “What colour do we want next?”
Bob slides the purple shape towards himself.
Researcher: (prompts) “Red…”
Bob: “Yellow”
Researcher passes Bob a yellow shape which he slides to the end of the row.
Researcher places a purple shape on the table. “And the last one is a… (Bob slides it to the end of the pattern) a purple one, well done!”
Researcher: “Now we are going to do the same thing with our blue and white rods Bob. So I want you to do me an alternating pattern with the blue and the white.”
Bob: “What are we going to do after?”
Researcher: “Well we’ll get through all of our jobs, then we’ll see what’s next. Do you want to start with blue or white?”
Bob: “Blue.”
Researcher: “Blue? (Places a blue rod on the table) now, we are going to alternate it with a white one. What colour do you want next?”
Bob: “White”
Researcher places a white rod on the table. “Pop your white one next then.”
Bob positions in line with the blue rod.
Researcher: “What’s next?”
Bob: “Blue”

Researcher: “Blue! There’s a blue one. (places a blue rod on the table) What’s next?”

Bob: “White”

Researcher: “Well done! (puts a white rod on the table) What’s next?”

Bob: “Blue”

Researcher adds a blue rod to the row. “What’s next?”

Bob: “White”

Researcher: “Well done!” (places a white rod in the row) “What’s next?”

Bob: “Blue”

Researcher adds blue to row. “What’s next?”

Bob: “White”

Researcher: “White! Well done! Right, now I’m going to push these up here Bob and we’re going to use the play dough to make the same pattern, using the play dough”

Bob puts hands in air and excitedly says, “Yes!” Bob asks for clarification (wording not audible).

Researcher: “We’re going to use the white and blue play dough Bob. Right, are we going to do sausages and balls? ”

Bob: “Sausages and balls.”

Researcher: “What colour sausages would you like?”

Bob: “Blue”

Researcher: “Blue! Right, you and TA make the sausages then. I want three sausages. (passes Bob a lump of playdough which he starts to roll. Passes two lumps to the teaching assistant). I’ll make some balls …actually we want four, sorry!”

Bob rolls the lump into a sausage shape. “Can I have a bit of help please?” (Teaching assistant helps).

Teaching assistant: “How many did we need?”

Bob: “We needed four”

Teaching assistant: “Ok, that’s good.”

Bob pauses to observe the teaching assistant. He then positions his first sausage. “I’m making a standing up sausage!”

Researcher: “Well done! When they’re finished I’ll have them over here, then you can tell me what you want.”

Bob passes researcher completed sausage and makes the next.
Researcher: “Ready? Got our four sausages? Is that one finished Bob?”
Bob: “Yes” (passes it to researcher)
Researcher: “Thank you, well done!”
Bob: “We’ve got four sausages.”
Researcher: (points to rods) “Right Bob, we’re going to copy this pattern here, using our sausages and balls.”
Bob: “I’ll stick them up!”
Researcher: “So which one do you want first? (points to pattern in rods) so, we are copying this pattern here Bob.”
Bob: “Blue, a blue one…cus, white…”
Researcher: “Right, put your blue one in the row then ”
Bob presses the white ball to ‘stick it’ to the table.
Researcher: “Then what do you want?”
Bob: “Blue!”
Researcher: “Blue!” (places a blue sausage on the table in an upright position)
Bob moves it slightly to his right and presses it to the table. “I’m sticking it down.”
Researcher: “What do you want next?”
Bob: “White!”
Researcher (Places the white ball on the table. Bob repositions it in the row.)
Researcher: “Then what do you want?”
Bob: “Then blue!”
Researcher: “Then a blue” (places it on the table. Bob repositions it.) Then what next?”
Bob: “Then a white.”
Researcher (Places white ball on table) “Then a white”
Bob repositions it and sticks it to the table using the palm of his left hand.
Researcher: “Then what?”
Bob: “Then a blue”
Researcher: “Then a blue!” (hands the blue sausage to Bob who takes it and positions it at the end of the row). “Then what Bob?”
Bob: “Then a white.”

Researcher hands Bob a white ball which he positions at the end of the row.

“Then a white! Then what?”

Bob: “Then blue!”

Researcher: “Blue!” (Passes Bob a blue sausage which he takes and positions at the end of the row.)

Researcher: “All done Bob, so you have matched it haven’t you?”