The Effectiveness of Precision Teaching when Working with Children with Attention Deficit Hyperactivity Disorder

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Abstract

A two-dyad multiple baseline design was used to determine if Precision Teaching (PT) was effective in improving the target skills of sight word recognition for two boys aged six and eight (Group A) and multiplication for a 12-year old boy and a 10-year old girl (Group B). The participants were all diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) and attended the Kauri Centre. SAFMEDS (Say All Fast Minute Each Day Shuffled) cards containing words or sums were used. Correct and incorrect responses were recorded on a Standard Celeration Chart. Group A also read from a reader, recalled facts about books previously read to them, and copied a passage of writing, while Group B answered sums on multiplication, division, and word problem worksheets. These measures were used to see if PT in a target skill had any effect on other classroom activities. Furthermore, aggressive behaviour, off-task behaviour, and responses to instructions were observed to determine if any changes occurred following the implementation of PT. The arrival of a new teacher, however, confounded these results. PT is a very effective method for teaching target skills to ADHD children, however there is limited application of this skill to other classroom activities and no new behaviours emerged as a result of the PT process. Future research could look at teaching this population other skills using PT and/or using PT to help other children experiencing reading or maths difficulties.

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Dedication

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The main clinical symptoms of ADHD are inattentiveness, overactivity, and impulsiveness at levels that are developmentally inappropriate (DSM-III, as cited in Barkley, DuPaul, & McMurray, 1990; Sagvolden, Johansen, Aase, & Russell, 2005). There are deemed to be three subtypes of this disorder, whereby either inattentiveness or hyperactivity/impulsiveness is predominant, or there is a combination of these two components (Sagvolden et al., 2005). The predominantly inattentive type of ADHD includes behaviours that exhibit "difficulty in sustaining attention, distractibility, lack of persistence, and disorganisation" (Sagvolden et al., 2005, p. 398), whereas the hyperactivity/impulsiveness type is characterised by an excessive amount of motor activity and a lack of inhibition in responding, i.e. an inability to delay responses to the environment (Lahey et al., 1998). One of these subtypes, or a combination of the two, affects 2% to 12% of grade-school children in America (American Academy of Pediatrics, 2000, as cited in Sagvolden et al., 2005). Considering the prevalence of this disorder in schools, it seems pertinent to examine what could be the most effective ways to teach such children.

This is particularly important because ADHD children have often been shown to lag behind the rest of their class academically and rates of failure are often high, particularly in the areas of mathematics and reading (DeShazo, Lyman, & Grofer, 2002; DuPaul, McGoey, Eckert, & Vanbrakle, 2001). For example, Lahey et al. (1998) found that the academic achievement of 4-6 year old children diagnosed with ADHD was significantly lower than their non-diagnosed peers. Similarly, Fischer, Barkley, Edelbrock, and Smallish (1990) found that children, aged 4-12 years old, who were experimentally diagnosed as being hyperactive (DSM-III-R was not published at this stage) were lower achievers academically than those in a control group. Masetti et al. (2008) also found that, during the course of a longitudinal study,

children with the inattentive subtype of ADHD (ADHD-I) had significantly lower reading, writing and maths scores than children with the other subtypes of ADHD or without ADHD. Barkley et al. (1990), however, stated that children with both types of ADHD have academic impairments and are kept back grade levels or placed in special education more so than a control group.

There is substantial evidence to suggest that children with ADHD exhibit academic difficulties yet most medication and behavioural management interventions for ADHD are aimed at improving attention and reducing disruptive and inappropriate behaviours, however there is very little research showing that such interventions have any effect on academic performance (Berthiaume, 2006). According to the MTA Cooperative Group (1999, as cited in Berthiaume, 2006), although stimulant medication can improve some of the symptoms of ADHD, it does little to improve academic performance. It is therefore important to look at alternative treatments for those with ADHD in respect to education (Berthiaume, 2006). It may be that children diagnosed with ADHD are not actually deficient in these skills but rather that the teaching methods in standard classrooms are not suited to their needs and/or that they spend so much time out of the classroom due to their disruptive behaviour that they are not adequately taught the curriculum. The cognitive abilities of ADHD children are not accurately represented by their academic performance, as their academic performance tends to be lower than what their cognitive abilities suggest they are capable of (Hinshaw, 1992); this is often because there are deficits in their performance, not their skills, whereby they tend to quit things more often and become frustrated more easily than their peers (Hinshaw, 1992). If, however, they were taught in a way that they were more responsive to their skills may improve. As such, it is important to combine interventions for ADHD behavioural related problems with

interventions based on academic achievement, as focusing on different teaching methods for these children may counterbalance the underachievement that appears to be related to ADHD, as current teaching methods are clearly not very effective. The following examines some of the techniques that appear to be effective in teaching children with ADHD.

Allsop, Minskoff, and Bolt (2005) conducted a three-year Model Demonstration Project looking at the effectiveness of instructing college students with learning disabilities and ADHD on an individual and course-specific basis. Appropriate learning strategies were chosen, based on an initial assessment of the students' individual learning needs, and were then taught using "systematic explicit instruction" (Allsop et al., 2005, p. 104), as students who struggle with learning seem better able to apply strategies if they are explicitly and systematically instructed on how to do so (Allsop et al., 2005). There is a strong evidence-base for this (e.g. Carnine, 1999; Swanson, 1999, 2001; Vaughn, Gersten, & Chard, 2000) and it relates to the notion that such students can find it difficult to extract the relevant information needed for a task (Zentall, 2005). As the students began to show an understanding of the strategy and how to apply it, the instructors gradually faded their role from one of guiding the student to allowing them to implement the strategy on their own. Feedback and positive reinforcement occurred throughout the process, and the students' use of the strategies was monitored (Allsop et al., 2005). The participants found the focus on individual needs, along with the support of the instructor, to be key factors in producing positive outcomes and the authors advise using these factors to help students with learning disabilities and ADHD to improve their academic performance (Allsop, et al., 2005). Zentall (2005) also highlights the need for teachers to provide specific instructions for students, and also stresses the importance of

matching the task level to the capabilities of the student before administering instructions. Furthermore, Ostoits (1999) proposes that instructional methods need to be consistent and that structuring daily schedules is effective. There is therefore support for the idea that altering the teaching methods available in schools for those diagnosed with ADHD can help them improve academically, as general classroom instruction may not be sufficient for these children.

Providing individual help and working on specific skills in small groups can also be beneficial (Ostoits, 1999). Burcham, Carlson, and Milch (1993) found that if specific feedback was provided directly to the student every 15 minutes that the student required less disciplinary action thus was able to remain in the classroom thereby increasing their chance of learning. Rief (1993, as cited in Ostoits, 1999) also proposed that the stimuli used for teaching and the material being taught needs to be "interesting, relevant, motivating, and multisensory" (p. 130). Actively participating and interacting are also considered important aspects in helping children with ADHD learn (Ostoits, 1999). Adding to this is Zentall's (2005) idea of teaching tasks to children with ADHD in a hierarchical manner, starting with tasks that begin simply and, after practice, become more difficult. Practice sessions for students with ADHD, however, are most effective when they are of a short duration (Zentall, 2005). Also, Leung, Leung, and Tang (2000) found that there was less, or no, difference in the levels of attention exhibited by ADHD students and their peers when they practiced tasks by responding in a fast paced and repetitive manner.

Setting goals on a daily basis is also considered an important aspect of improving academic performance (Zentall, 2005); the achievement of goals is therefore a further area that could be looked at when trying to determine the most effective ways for teaching children with ADHD, as the "type of goal adopted shapes

how students approach, experience and react to their schoolwork, and has an influential impact on the affect, behaviours, and cognition they experience" (Dweck, 1986, cited in Barron, Evans, Baranik, Serpell, & Buvinger, 2006, p. 138). The way goals are set and achieved could be different for children with ADHD compared to children without this diagnosis and as such an understanding of this could be beneficial when designing ways to improve the academic achievement of these students (Barron et al., 2006). Ames (1992) proposed achievement goal theory as being a way of understanding why people engage in behaviours that are related to achieving goals and how success is evaluated. There are two types of goals proposed, these being mastery or performance oriented goals (Barron et al., 2006). The former refers to the acquisition of new knowledge and skills and is evaluated by personal standards or the ability to perform a task whereas the latter is based on comparisons with others (Barron et al., 2006). Elliot (2005) divided performance goals into approach and avoidance goals with the latter focusing on attempting to not be the worst at something. Barron et al. (2006) found that although ADHD students adopted a mastery goal orientation for their schoolwork, they exhibited above average levels of performance-avoidance goals in terms of their coursework than non-ADHD students. This is a unique finding and shows that "performance-avoidance goals may be providing some students with some motivation to remain focused on academics, and striving to not be the worst may be a helpful motivator for this population" (Barron et al., 2006, p. 155). The use of mastery goals is also important though because this could link with the idea of self-management, as students could learn to evaluate their own academic performance and as such strive to better their performance. The idea of self-management is now further discussed.

Self-management is a strategy that seems to be effective in improving the classroom behaviour of children with ADHD (Shapiro, DuPaul, & Bradley-Klug, 1998). Introducing self-management skills is done on continuum ranging from the teacher evaluating the student's behaviour and providing appropriate consequences, to the student evaluating their own behaviour and administering their own consequences (Shapiro et al., 1998). A process developed by Rhode, Morgan and Young (1983) exemplifies the use of the aforementioned continuum, as target behaviours are identified and given ratings first by the teacher and then by the student and teacher, until the student is managing his/her own behaviour. Initially rewards are received based on the points value of the rating and then this is also faded out (Rhode et al., 1983). Shapiro et al. (1998) conducted two case studies based on this continuum and found that targeted behaviours improved when a self-management programme was implemented. This shows that gradually fading out support from the surrounding environment whilst reinforcing self-evaluation can have positive effects on behaviour; this self-management technique could translate to improvements in other areas, such as academic performance, as discussed below.

Recording performances and evaluating them based on previous performances helps students monitor their own academic progress (Zentall, 2005). Self-monitoring, through the use of individual charting or evaluation of academic performance, has been "demonstrated to increase the number of academic problems attempted, number correct, task-persistence, and on-task attention" (Zentall, 2005, p.827). Combining this with an added reinforcement, such as stickers, for achieving their goal, increases the effectiveness of self-monitoring and evaluation (Zentall, 2005). In particular, primary reinforcers have been effective in increasing the amount of attention given to a task, as shown by Worland, North-Jones, and Stern (1973, as cited in Zentall, 2005),

who found that hyperactive children performed better than their peers in attending to the task when candy was used as a reinforcer. Increasing the amount of reinforcement, as well as the intensity and immediacy of positive feedback "can provide increased stimulance to help students with ADHD sustain attention" (Zentall, 2005, p. 830). Combining reinforcement with self-management techniques can therefore be an effective way of teaching children with ADHD.

In line with this idea of self-management being beneficial to students diagnosed with ADHD is the practice evident at the Albany Free School in upstate New York (Jacobs, 2005). This school accepts children who were not performing well at normal schools and many of these children have been, or are at risk of being, diagnosed with ADHD (Jacobs, 2005). The central idea operating within this school is that:

> If children are empowered to chart their own courses for learning, if they are given the freedom and responsibility for developing their own rules, if they can develop their own structure, and if they can follow their own timetable for learning, they will become eager, willing, and confident learners who respect themselves and others. (Jacobs, 2005, p. 171-172)

There appears to be some controversy surrounding this school in terms of its extreme approach to empowering students, however it does add support to the idea that allowing students with ADHD some degree of autonomy over their education may be beneficial in improving their academic performance.

Overall academic deficits are prevalent in students with ADHD, however these deficits may be due to performance problems, as opposed to actual learning disabilities. It is therefore important to examine various teaching methods that may benefit such students, as currently most interventions only focus on increasing

attention or decreasing problematic behaviour yet there is no link between this and improving academic performance. Teaching methods that appear to be effective are those that are focused on the individual needs and capabilities of each student, only gradually increase in difficulty, use specific, explicit and systematic instruction, provide frequent but short practice sessions, provide high rates of positive reinforcement and incorporate a degree of self-management. A combination of these techniques in the classroom could aid in improving the academic performance of children diagnosed with ADHD. PT is a particular method that appears to match many of these learning requirements; the following section first outlines the basis of PT and then illustrates how this method could be an effective way of teaching ADHD students.

Precision Teaching and ADHD

PT was first developed in 1964 by Ogden Lindsley, with the aim of enabling students and teachers to make better educational decisions about individuals based on data collection and specific processes for measuring performance, thereby bringing science into the classroom (Binder, 1988; 1996). The premise behind PT is that composite skills are broken down into their component parts and mastery must be achieved for each component before moving onto the next level (Binder, 1988). Problems in areas such as reading and writing, that were once thought to be learning disabilities, have been shown to reduce when students are given the opportunity to practice basic skills until they can perform them with both speed and accuracy, as it is the combination of these two factors that leads to competent performance (Binder, 1996). It was initially Skinner (1938, as cited in Binder, 1996) who proposed that response rates are essential for measuring the strength of a behaviour, and Lindsley

"relied on cumulative response records of behaviour frequencies as the basic measurement and analysis technology" (Binder, 1996, p.166); it was ultimately this focus on frequencies that led to PT (Binder, 1996). Mastery is defined by previously set criteria and practice, in the form of daily one-minute timings, is deemed to be the key to achieving mastery at each level (Binder, 1996). The number of correct and incorrect responses obtained during these timings are recorded on a Standard Celeration Chart; it is through reading this chart that decisions can be made about the next stage of each student's progress, as the celeration i.e. the learning rate of each student, is depicted (Pennypacker, Koenig, & Lindsley, 1972; White & Haring, 1980). The Standard Celeration Chart is also used to set goals, or performance aims, and to make adjustments to the program based on whether or not the student is reaching these aims (Binder, 1996). Ultimately, the objective of PT is to increase the frequency of correct responding, as speed and accuracy are the two key factors of fluency. Fluency is the key to competent performance, as will now be discussed.

It has often been thought that accuracy is the most important factor in determining if somebody is capable of performing a skill, however accuracy merely accounts for the number of responses that are correct or incorrect and uses the percentage of correct scores as an indicator of competency, whereas fluency incorporates the rate of responses in assessing performance (Binder, 1988; Doughty, Chase, & O'Shields, 2004). A person may be accurate in that they get all the responses correct, however it may take them a long time to respond. A fluent person, on the other hand, is able to respond accurately and quickly, meaning that they have not merely acquired the skill but are able to perform it in a useful way (Binder, 1988). It is only when a skill becomes automatic that it is useful because this means it is always remembered and can be applied when necessary (Johnson & Layng, 1992).

Without considering the rate of responding, it is unknown how well someone is actually performing, as accuracy alone does not indicate how "many opportunities there were for responding … [and] … how much time was required to complete the work" (Binder, Haughton, & Bateman, 2002, p. 3). In order to set goals for student's performance and to accurately monitor the achievement of these goals, a time component must be incorporated (Binder et al., 2002). Being able to perform a behaviour or skill with high frequency is deemed to be indicative of retention, endurance, stability, application and adduction of that skill; these are used as further measures of assessing fluency (Doughty et al., 2004). Retention means that the skill can be performed at the same rate after a period of not practicing it (Doughty et al., 2004). Endurance shows that the skill can be maintained for an appropriate duration and stability means that the behaviour will still occur in the presence of distractions (Doughty et al., 2004). Fluency is also demonstrated if the skill can be applied in the natural setting and aids in the building of more complex behavioural repertoires (Doughty et al., 2004). Following is an example of the difference between fluency and accuracy.

The ability of a person to perform multiplication sums illustrates the importance of being fluent in this skill, rather than simply accurate. One person may provide the answers to the five times tables correctly but do so by literally counting in groups of five, a process which takes a considerable amount of time. Another person, however, may say the correct answers instantly hence responding at a high rate, indicating fluency in the five times tables whereas the other person is merely accurate. To be truly fluent, this latter person would also remember the fives times table after a period of no practice, show endurance and stability, and be able to apply knowledge of the five times tables in their everyday life plus be able to perform other

multiplication problems. In order to exhibit fluency in the five times tables, however, fluency would first have to have been achieved in the component skills that are necessary to perform this composite skill, an issue that will now be addressed.

If fluency in one skill is not mastered before moving onto the next level of learning then difficulties will arise at this next level (Binder, et al., 2002). This is especially important in the education setting because if children have not mastered a prerequisite skill for a more complicated skill then they will have difficulty performing this latter skill. This is known as cumulative dysfluency and it is increasingly becoming identified as a primary reason for students enduring failure throughout their school years (Binder, 1988; Johnson & Layng, 1992; Pennypacker & Binder, 1992, as cited in Binder, 1996). Students suffering from cumulative dysfluency may become frustrated with not being able to do the work thus may engage in avoidance behaviours (Binder, Haughton, & Van Eyk, 1990). Not only this, but "the result of piling too many non-fluent skills on top of one another is emotional stress, a sense of being overloaded, lack of attention span, and in extreme cases dropping out from school" (Binder et al., 2002, p. 3). Self-confidence may also be lowered (Binder et al., 2002). If fluency is not achieved in basic skills then it is likely the student will find it extremely difficult to perform the composite skill so will probably take a considerable amount of time to do so and emit many mistakes (Binder et al., 2002). If fluency is taught at each level then students are better equipped to move onto the next level, meaning that they transition smoothly between academic stages (Binder et al., 2002). Adding to this, an ability to perform the basic skills automatically means that attention no longer has to be focused on how to perform a particular task but instead attention can be given to gaining a higher understanding of something i.e. "fluency in foundation skills frees attention for application, creativity,

and problem-solving – the higher-order activities that make education valuable and fun" (Binder et al., 2002, p. 5). For example, if student's are struggling with the basic components of reading, such as sight word recognition, then all their attention is focused on decoding the words whereas if this skill was automatic they would be able to apply more attention to understanding what they are reading and may therefore enjoy reading more. Fluency training would enable the student to learn each component of reading in a hierarchical fashion. Teaching fluency, rather than merely accuracy, in basic skills is therefore essential for academic progress because the student acquires the component skills necessary for a composite behaviour (Binder et al., 1990). One of the most effective ways of measuring fluency is by counting the number of times a person can perform a repeated task in a fixed period of time and this is characteristic of PT (Binder et al., 2002). The premise behind PT has now been outlined so the similarities between this teaching method and the learning requirements of those diagnosed with ADHD will now be conveyed.

A key factor of PT is matching tasks to the ability of each student and the difficulty of tasks is only increased when mastery, based on a specific set of performance criteria, has been achieved (Binder, 1996). Focusing teaching on the individual capabilities and learning needs of students with ADHD has been shown to be beneficial in improving their academic performance (e.g. Allsopp et al., 2005; Ostoits, 1999), as has teaching simple tasks first and slowly increasing the difficulty of the task over time (Zentall, 2005). Matching tasks with capabilities and only gradually increasing the difficulty of these tasks is therefore characteristic of both PT and the learning needs of students with ADHD.

Studies have shown that ADHD students also perform better when they receive some form of positive reinforcement (Zentall, 2005), and when tasks are

matched with ability, improvements often become evident and this in itself can be positively reinforcing. ADHD students also often respond positively to secondary reinforcement and sometimes reinforcers, such as stickers, are used when performance aims are met in PT (e.g. Hartnedy, Mozzoni, & Fahoum, 2005). Regular positive feedback about their progress can also be beneficial when teaching students with ADHD (Burcham et al., 1993) and considering PT is conducted on a daily basis and the results are evident on the Standard Celeration Chart (Binder, 1996), if performance improves, this may be sufficient positive feedback. The addition of any secondary reinforcement for the attainment of performance aims could further improve academic performance, as ADHD students have been shown to work better when secondary reinforcers are involved (Zentall, 2005).

The attainment of goals is an important factor in PT, as progress through a program only occurs when set mastery criteria have been met (Binder, 1996). Barron et al. (2006) found that ADHD children adopted a mastery goal orientation in regards to their schoolwork, whereby the achievement of goals is acquired by the acquisition of new knowledge or skills and it is evaluated based on personal standards or the ability to perform a task. The achievement of performance aims in PT therefore suits ADHD children, as they would be attempting to acquire a skill whilst simultaneously measuring their progress based on their own performance or ability to do something. In relation to these performance aims that are set as part of PT, are instructions about when phase shifts should occur i.e. at what stage the task should increase or decrease in difficulty (Binder, 1996). This ties in with studies that have shown that those suffering from ADHD achieve better results when instructions are specific, explicit and systematic (Allsopp et al., 2005).

ADHD students also seem to work best when they are given some responsibility for their own work and are able to monitor their own progress, particularly through the use of graphs depicting their performance (DeHaas-Warner, 1991, as cited in Zentall, 2005; Shapiro et al., 1998). This links directly with PT, as PT has been shown to work best when students record their own performance and make their own decisions (with advice from teachers) about their progress (Binder, 1988). Also, the Standard Celeration Chart graphically depicts this progress (Binder, 1996). Studies have also shown that those with ADHD seem to achieve the best results with lots of practice but only if practice sessions are of a short duration (Zentall, 2005). PT utilises daily practice sessions of one minute duration (Binder, 1996) therefore these short but frequent practice sessions suit the learning needs of ADHD students.

PT could therefore be an effective way of teaching those with ADHD, as it incorporates the specific learning needs of such students. Matching tasks with individual capabilities and only gradually increasing the difficulty of these tasks, self-management, specific rules, short but frequent practice sessions, performance aims, feedback, and graphic representation of results are all key factors of both PT and how those with ADHD tend to learn best. Some teachers have expressed concern that the individual focus of PT would take up too much time and be too much for them to handle in the classroom, however it has been shown that PT can actually leave more time for teaching, not less, and that students and teachers are quick to become confident and proficient in the PT techniques (Beck & Clement, 1991). It is therefore a teaching method that could be easily implemented in the classroom and be beneficial in improving the academic performance of those with ADHD. Two specific areas where academic deficits are often evident in students with ADHD are reading

and maths; PT has been shown to be particularly effective in improving these skills (e.g. Chiesa & Robertson, 2000; Downer, 2007), as outlined below.

The Great Falls Precision Teaching Project demonstrates the effectiveness of PT in both special education and normal classrooms (Beck & Clement, 1991). PT was firstly used in Great Falls as a method to help handicapped children increase their skills in the areas of mathematics, reading and spelling (Beck & Clement, 1991), however teachers in Sacajawea believed that students in normal classrooms could also benefit from PT, as some students exhibited deficits in these skills and it was thought that this could be attributed to deficits in the component skills that are required to be able to perform fluently in these areas (Beck & Clement, 1991). Only 30 minutes per day was used for PT and it was found that there were improvements in achievement tests of between 20 and 40 percentile points (Beck & Clement, 1991). Furthermore, in 1979 a study was submitted to the Office of Education that had found that students at normal schools who had received PT for reading, maths, and spelling performed better than students at other normal schools who had not been implementing the PT method (Beck & Clement, 1991). A further study showed that, although a control group performed better at maths and reading on a pre-test, after PT was implemented in the test group, this group scored higher on the post-test (Beck & Clement, 1991). In 1981 PT was formally named as a valid method for teaching maths and English in schools (Beck & Clement, 1991). The following two sections illustrate the effectiveness of using PT to improve reading and maths performance, with a particular focus on the necessity of providing alternative teaching methods in these areas for students diagnosed with ADHD, as previous studies have shown that the academic performance of students who were considered to be failing subjects improved significantly when teaching methods were used that suited their particular

style of learning (e.g. Brunner & Majewski, 1990; Dunn & DeBello, 1999). ADHD students exhibit unique characteristics and it is important for teachers to cater to these needs in the classroom setting if such students are to achieve their potential academically (Brand, Dunn, & Greb, 2002; Ostoits, 1999).

Reading

Reading is one area where the implementation of different teaching methods could be effective in enhancing students' performance (Ostoits, 1999). This is an important area because, although they do not necessarily have a specific reading disability, many children that suffer from ADHD also suffer from reading difficulties (Ostoits, 1999). Reading deficits are based on weakened phonological and comprehension skills whereas reading difficulties related with ADHD are more likely due to deficits in executive functioning and impulse control (Aaron, Joshi, Palmer, Smith, & Kirby, 2002). ADHD children tend to have reading difficulties due to being inattentive and off-task therefore they do not process information accurately and perform poorly on tests of reading comprehension (Aaron et al., 2002). French and Landretti (1995) proposed that this poor reading ability, along with other academic difficulties, is due to a "breakdown in the attentional regulatory system" (p. 11). Although this may be the case, teaching methods designed to cater for this problem should enable such students to improve their reading ability. The way that inadequate readers learn is usually different to the way children are taught in schools (Wallace, 1995); it is therefore essential to teach such readers in a style better suited to their needs if they are to improve their reading performance. Adding to this is the need to make a distinction between those with reading deficits and those with reading difficulties, otherwise children suffering from reading difficulties due to ADHD may phenotypically appear to have a reading deficit, or vice versa, and as such appropriate

treatments are unable to be developed (Aaron et al., 2002). It may be difficult to make this distinction, especially because diagnoses of ADHD are subjective and opinion based, however children with reading deficits tend to be better at listening tasks due to their decoding problems with reading, whereas children with ADHD tend to be better at reading than listening due to the extra attention required of listening tasks (Aaron et al., 2002). The focus here is on students with reading difficulties due to ADHD and Ostoits (1999) has looked at a number of different interventions aimed at improving the reading ability of these students, as outlined below.

In regards to reading, pre-reading strategies such as the Fernald kinaesthetic method (Warren & Flynt, 1995), and post-reading strategies such as story mapping (Wallace, 1995), are alternative teaching methods that can help improve the reading ability of students with ADHD. Ostoits (1999) states that the students he works with have problems remaining attentive, making it hard to keep these children involved in a text long enough to be able to comprehend it. This may be a problem that needs to be delved deeper into, as it may be that part of the reason these students divert attention from the text relatively quickly is because too much attention is focused on decoding the words. Two important components that constitute reading are word recognition and comprehension, with word recognition consisting of decoding and sight word reading (Aaron, Joshi, & Williams, 1999; Gough & Tunmner, 1996). Quite possibly, if their sight word recognition is improved, they may engage in the text for longer, as more attention will be able to be spent on understanding the text. In line with this, Zentall and Myer (1987) found that children both with and without ADHD were able to read words with greater accuracy if they were given words to read in an ascending order of lesser to greater difficulty. The following example illustrates the

effectiveness of PT in improving sight word recognition in a sample of infant, junior and secondary school pupils.

Sixteen teaching assistants were trained in PT with the aim of improving the participants' sight recognition of some high frequency words (Downer, 2007). On a daily basis for 26 weeks, the children were individually taught five target words or they revised the previous words they had been taught (Downer, 2007). The number of words they could read aloud in one minute was tested and the results were charted on a graph; the set criterion was to be able to read 50 words in a minute (Downer, 2007). The outcomes for the infant and junior schools were measured by the number of new words the child could recognise, whereas the secondary school children's outcomes were measured by any changes in their reading age (Downer, 2007). The infant and junior school pupils learnt an average of 2.15 and 3.61 new words respectively each week; both statistically highly significant results (Downer, 2007). The average increase in reading age for the secondary school pupils was 3.96 months, also a highly significant result (Downer, 2007).

Beneke (1991) also used PT to enhance reading performance, however the students in this study were at university level, and the aim was to increase reading speed and comprehension. Each day, for one minute, the students were required to read a text and then for the following minute they had to write down as much information as they could remember from the text (Beneke, 1991). The participants improved over the semester in terms of both the speed and comprehension of their reading, whereas the control group showed no improvements in speed and only slight improvements in comprehension (Beneke, 1991). Similarly, McDade, Cunningham, Brown, Boyd, & Olander (1991) found that recording one-minute timings of reading on a daily basis resulted in faster reading and improved comprehension. PT can

therefore be an effective method for increasing fluency in reading, and the importance of fluency in this area will now be discussed.

Being able to read fluently is essential for being able to engage in text at a level that produces meaning for the reader (Kuhn & Stahl, 2003). Achieving fluency at this level requires fluency in the component skills that constitute the composite skill of reading and one of the key stages that leads to this is moving from reading words slowly and separately to connecting words in a text in a correct and speedy manner (Kuhn & Stahl, 2003). This is considered important, as if reading words is not automatic then too much attention is spent on deciphering the word, subsequently leaving little attention for comprehending the text (Adams, 1990; LaBerge & Samuels, 1974). There have however been more stages identified in the development of reading through various models, such as those developed by Chall (1996), Ehri (2005) and the University of Orgeon's 5 Big Ideas In Beginning Reading (University of Oregon Centre on Teaching and Learning, n.d.), and these typically range from pre-alphabetic reading behaviours, to an awareness of the association between sounds, letters and words, to the instant recognition of words, and finally comprehending and extracting meaning from a text.

The ability to read words by sight is deemed to be an essential component in the overall skill of reading and this can occur with practice, however an awareness of phonemes and a sound knowledge of alphabetic principles is first required if sight word recognition is to be developed (Ehri, 2005). Ehri (1991) identifies four different ways of reading words but proposed that the most efficient way to read words is to know them by sight. The other ways involve decoding words based on their phonemes and graphemes, using words that are known to decipher unknown words based on their similarities, or by using the context and letters to guess words (Ehri, 1991).

These three processes require the reader to focus much of their attention on identifying the word and as such, there is little capacity left for comprehending the text whilst reading it (Ehri, 2005). If words are recognised automatically by sight though, attention can be given to understanding the meaning of the text and this makes for a much more efficient way of reading (Adams, 1990; Ehri, 2005; LaBerge & Samuels, 1974).

Gaining a meaningful understanding of the text is the main purpose of reading and in order to achieve this purpose, fluency in sight word recognition is required (Kuhn & Stahl, 2003). Kuhn & Stahl (2003) propose that decoding words accurately and recognising words automatically are main components of fluent reading. Similarly, Johns (1993, as cited in Kuhn & Stahl, 2003) stresses the importance of accurate word recognition in the comprehension of text and Nell (1988, as cited in Kuhn & Stahl, 2003) stresses its importance in terms of enjoying reading. Increasing sight word recognition through practice is therefore considered to be an essential component of being able to read fluently. PT is therefore a method that could be used to improve reading performance by building fluency in the component skill of sight word recognition through the use of daily one minute practice sessions of a selection of words and recording individual performance on a Standard Celeration Chart that is then used to guide decisions about the next stage of the students reading progress. As many of the aspects involved in PT suit the learning requirements of those diagnosed with ADHD, then increasing the sight word recognition of ADHD students using PT could be an effective way of improving their reading skills, an area where they have shown to exhibit deficits.

Mathematics

Difficulties in mathematics are evident more often in children with ADHD than students from the normal population, with one in five children with ADHD experiencing difficulties in maths (Capano, Minden, Chen, Schachar, & Ickowicz, 2008). There are therefore some students with ADHD that do not experience difficulties in maths so ADHD cannot solely account for these difficulties, however symptoms of ADHD may lead to poor maths performance. For example, Zentall, Smith, Lee, and Wieczorek (1994) found that the ability to do maths was affected by higher levels of hyperactivity. Zentall et al. (1994) also suggested that ADHD children had difficulty in applying mathematical rules and principles to solving maths problems. An underlying reason for deficiencies in maths has not been found, however it is thought to be contributed to by "poor reading-related skills, memory, visuospatial skills, and executive skills" (Capano et al., 2008, p. 393). Barry, Lyman, and Klinger (2002) found that ADHD students performed significantly lower in reading, writing and maths tasks in comparison to non-ADHD students, and stated that

> deficits in executive functions such as planning, organising, maintaining an appropriate problem-solving set to achieve a future goal, inhibiting an inappropriate response, or deferring a response to a more appropriate time, representing a task mentally (in working memory), cognitive flexibility, and deduction based on limited information (p. 260)

may contribute to deficits in the mathematic ability of students with ADHD.

ADHD students seem to have difficulty in constructing a mental representation of their comprehension of mathematical problems (Lucangeli & Cabrele, 2006). It is thought that working memory is an important aspect of being

able to accurately depict a problem mentally, and deficits in this area of executive functioning may contribute to the difficulties ADHD children can have in solving maths problems (Lucangeli & Cabrele, 2006). In particular, this failure could be due to more irrelevant, than relevant, information being recalled (Lucangeli & Cabrele, 2006). Marzochhi, Cornoldi, Lucangeli, De Meo, and Fini (2002) found that children with attention problems could perform at levels equal to other children when problems only contained the necessary information but when irrelevant information was included they performed more poorly. This links to problems associated with working memory, as the irrelevant information may reduce the capacity of the working memory needed to respond appropriately to the task (Lucangeli & Cabrele, 2006). Processes concerned with the capacity of a student to attend to a task can also be part of the executive functioning system and as such, the poor attentional span of ADHD children may contribute to their difficulties with maths. There are also links between maths difficulties and reading difficulties in ADHD students, and as reading difficulties have been linked to a disorder in terms of the phonological processing aspect of the language system, it is thought that this may also play a part in poor maths performance (Capano et al., 2008).

Furthermore, Zentall et al. (1994), found that not only were boys with ADHD less competent than non-ADHD boys in terms of mathematical problem solving and conceptualisation, but their ability to recognise and type numbers, as well as their computation skills, were also slower in regards to addition, subtraction and multiplication. They were also less accurate in terms of their calculation and this slow and inaccurate performance may be attributed to being easily distracted, as well as their hyperactive and impulsive tendencies (Zentall et al, 1994). It could also once again be due to too much information in the working memory thereby requiring more

effort to focus on the relevant aspects of the problem thus slowing down their ability to calculate the answer.

Overall, it is unknown exactly what factors contribute to the mathematical deficits in students with ADHD, although it appears that it could be due to deficits in the executive functioning of these students. Regardless of the reasons behind it, these deficits are quite predominant in ADHD students and as such, effective methods of teaching them maths are required. If numeracy is not attained, it can have negative impacts across the lifespan, proceeding from difficulties with education to difficulties in the workplace and other areas (O'Donoghue, 2002). Maher and Weber (2009) also consider competency in maths to be important for later in life and stress the importance of first being competent in basic maths skills. Ensuring that fluency is achieved in basic maths skills before moving onto more advanced skills is therefore essential for eliminating dysfluency and subsequently mathematic failure, as well as being beneficial during adulthood.

PT is concerned with building upon base skills in order to perform higher level composite tasks efficiently, and as such it is an effective method for teaching maths. For example, students must first be fluent in basic number-writing and digit-reading skills before further skills, such as addition, subtraction, multiplication, and division, can be effectively learned (Gallagher, 2006). Once mastery in the prerequisite skills has been achieved, students require fluency in the next level of skills, such as the multiplication tables, in order to be able to successfully apply these skills to more difficult maths tasks. Gallagher (2006) found that the use of PT in building multiplication skills to a level of fluency resulted in improvements on a composite task. Gallagher (2006) also discovered that adding a number writing component to the PT method for three participants who were struggling with learning their

multiplication tables led to improvements on this latter skill. Breaking down composite maths skills into their component parts and ensuring, through the use of the PT method, that fluency is achieved at each level before moving onto the next level can be an effective method for advancing the mathematic performance of students, as the following two examples illustrate.

Hartnedy et al. (2005) conducted an intervention using PT for two children with neurological and psychiatric problems, including ADHD, with the aim of increasing fluency in the basic skills of identifying the numbers 0-12 for one participant and answering multiplication problems that involved single digits for the other participant. PT was conducted using SAFMEDS cards and it was found that total response rate (corrects plus incorrects) increased for both participants and a reduction in errors was recorded (Hartnedy et al., 2005). Overall, participant 1 became more fluent in identifying the numbers 0 -12, and participant 2 became more fluent in answering multiplication questions (Hartnedy et al., 2005). PT was therefore effective in improving these base skills and as such the next level of skills could be taught using PT in order to build towards fluency in higher level mathematics. PT could provide the opportunity for these children to catch up to the performance levels of the rest of the class, whereas without PT these two children could have been swamped by attempting to learn maths without having first acquired the basic skills and as such they would have probably continued to endure academic failure.

Similarly, Chiesa & Robertson (2000) conducted a study using PT to improve the mathematic performance of five 9-10 year old children who seemed to be behind the rest of their class in mathematics. The remaining 20 pupils in the class were used as a control group. The composite math skill to be built to fluency was that of being able to divide two digit numbers by one digit numbers less than and including five,

with remainders (Chiesa & Robertson, 2000). Multiplication was identified as being a component skill of this so practicing and becoming fluent in the one through to five times tables was the first task of the PT group and once mastery was achieved in this skill they were taught that division is the inverse of multiplication; the next step was therefore to find the missing factor in a division sum and instruction then proceeded to division with no remainders then with remainders (Chiesa & Robertson, 2000). A pre-test on the composite skill had been administered to the control and PT groups and following the 12-week programme, both groups were once again tested on the composite skill (Chiesa & Robertson, 2000). The results showed that the average score for the PT group increased from 1 to 13.2, while the average score for the control group only increased from 3.7 to 4.2, when compared with the pre-test (Chiesa & Robertson, 2000). The PT group had 10-15 responses per minute more after training than before and the control group showed a decline in the amount of correct responses by some participants and only a slight improvement by others (Chiesa & Robertson, 2000). This study also showed that PT can be implemented in classrooms without any additional time or teachers needed, and only limited extra resources, therefore it is not only an effective method of improving math performance but it is also a more cost-effective procedure than remedial tuition, which is where these children may have been heading (Chiesa & Robertson, 2000).

As has been shown in the previous two sections, finding alternative methods to teach reading and maths skills to ADHD students is important, and one particular method for improving their performance in these areas could be PT. PT in one skill has been said to lead to the application of this skill in other areas and for new skills to sometimes emerge without being directly taught. This is an area that will be examined in the following section.

Application and Adduction

PT is a method aimed at building fluency in a particular skill area, however fluency is not only measured by a person's ability to perform the trained skill at a set criteria of speed and accuracy, but to also show retention, endurance, stability, application and adduction of that skill (Doughty et al., 2004). The first three concepts are relatively simple to measure. Firstly, the skill can be tested after a period of no practice to determine if performance still meets the previously set criteria. Secondly, the duration the skill must be performed for can be gradually increased to see if the performance criteria are still met. Thirdly, distractions can be present to see if they interfere with meeting the set performance aims. Application and adduction are slightly more difficult to measure but these are two very important issues pertaining to fluency, as they regard the incorporation of the skill that has been taught into other settings and the emergence of new behaviours (Doughty et al., 2004). The higher the frequency of accurate responding during the PT sessions, the greater the probability that these aforementioned measures of fluency will be attained (Binder, 1996). For example, Orgel (1984, as cited in Binder, 1996) found that when college students were tested on calculus formulas and rules six weeks after the completion of a PT program, those who were able to say more than 50 facts per minute during PT proved to be almost twice as accurate than students who had not attained such high levels of frequency during training. Furthermore, Binder (1987, as cited in Johnson & Layng, 1992) found that when participants learnt numbers corresponding to Hebrew letters to 100% accuracy, they were only able to add these letters in the presence of a distraction in the form of a voice speaking random numbers if they had achieved high rates of initial responding when pairing the numbers and letters. This indicates that high frequencies of responding during PT can lead to stability and as such building

fluency may be advantageous in decreasing the distractibility levels of students diagnosed with ADHD (Binder et al., 1990). Increasing the frequency of responding during PT sessions therefore has positive effects on the retention and stability aspects of fluency, as is also the case with application and adduction, which will now be discussed.

Binder (1996) stated that composite skills are learnt and performed more rapidly following higher frequencies of performance of component skills. Furthermore, building the frequency of component skills to a sufficient level can result in entirely new behavioural repertoires developing without any direct training (Binder, 1996). For example, Binder (1979, as cited in Binder, 1996) taught four disabled students to read, by sight, words that already existed in their vocabulary and discovered an emergent relation whereby the students demonstrated an increase in the frequency of being able to match words to objects and follow written instructions. These factors were not specifically taught yet they emerged due to the training of reading words by sight. This could be particularly useful in the classroom setting, as using PT to teach the components of a skill, such as reading, to a student, may result in the application of this skill in other areas of the classroom, such as completing a worksheet that involves some sort of word identification. In addition to this, the student may improve their performance in a writing task; this would be evidence of adduction, as although no writing skills were directly trained, they may appear due to the training in reading skills. The more components of various behaviours that can be performed at high frequencies, the more chance there is of adjusting to novel situations and building upon existing behavioural repertoires (Binder, 1996). It is thought that the "key to accelerating learning ability is to maximise the frequency of as many critical behaviour components as possible in the repertoire of an individual"

(Binder, 1996, p. 184-185), as building high frequencies of component behaviours provides a greater opportunity for developing composite or new behaviours (Johnson & Layng, 1992), as the following example illustrates.

Bucklin, Dickinson, and Brethower (2000) taught two component skills to either a standard of high accuracy only or of high accuracy and high frequency. The first component skill consisted of learning 10 arbitrary associations between Hebrew characters and nonsense syllables (Bucklin et al., 2000). The second component skill focused on learning associations between Arabic numerals and nonsense syllables (Bucklin et al., 2000). The application of these components was then tested in a novel situation whereby the participants had to write the answers to Hebrew arithmetic problems in Arabic numerals (Bucklin et al., 2000). Bucklin et al. (2000) found that those participants in the condition that included rate of responding answered more questions correctly per minute than those that were trained to accuracy alone. Both groups however portrayed similar levels of accuracy (Bucklin et al., 2000). This indicates that fluency in composite skills is more likely to be achieved if fluency, not just accuracy, is first achieved in component skills; complex skills are also acquired more easily if component skills are fluent (Bucklin et al., 2000). The following examples further support the idea that PT can lead to the application of skills and contingency adduction.

Contingency adduction was demonstrated with four students from Malcolm X College where the composite skill of being able to perform word problems with fractions was achieved by separately training the two components of this skill, these being whole number problem solving, and calculating with fractions (Johnson & Layng, 1992). Initial testing before training these components to high rates of speed and accuracy showed that participants only obtained three to seven correct scores out

of a possible 14, however after training they achieved 13 or 14 correct responses on the composite skill (Johnson & Layng, 1992). This composite skill was a novel task, as no direct instruction had been delivered on it, yet the students were able to perform it (Johnson & Layng, 1992).

Beneke (1991) found that administering PT methods to psychology students to help improve their reading speed and comprehension not only showed positive results in this area, but record attendance was evident at the classes PT was implemented in, indicating that PT evoked an increase in a different behaviour i.e. class attendance, to the skills being taught; this is characteristic of contingency adduction. Beneke (1991) also stated that "statistical analyses indicated that end-of-course reading and comprehension rates together accounted for 19.9% of the final exam variance" (p. 39). It is therefore possible that PT aimed at improving students' rates of reading speed and comprehension may have adduced into the behaviour of better exam performance, or the application of this new skill during exams gave rise to better results.

Peladeau, Forget, and Gagne (2003) focused on improving the component skills required for successful problem solving and tested academic performance during the course and at the end of the course, comparing the students' performance on tests within the semester and final exams. The idea was to see if practicing the components skills of problem solving to a level of mastery would lead to an application of this skill in tests and exams thus leading to better results, and it was found that exam scores did improve following such practice (Peladeau et al., 2003). Peladeau et al. (2003) stated that academic performance is positively affected by practicing skills until mastery has been achieved. Subsequently, the newly acquired skills are not only applied in various academic areas, but such skills can also lead to

new behaviours that constitute better academic performance. The Great Falls Project also showed that daily timed practices led to improvements of between 19 and 44 percentile points on subtests of the Iowa Test of Basic Skills (Beck & Clement, 1991). This shows that the skills learnt during PT were applied to the Iowa Test of Basic Skills, subsequently resulting in substantial improvements in test scores.

Downer (2007) found that PT focusing on the sight word recognition component of reading improved this skill and also suggested that overall reading performance was enhanced, however this was not specifically measured. If it was measured though, it may have been found that the application of sight word recognition to other areas of reading in the classroom may have resulted in better reading performance than before PT was implemented. Downer (2007) also suggested that there were improvements in the student's confidence, self-esteem, and temper control but not only was there no indication as to how these were measured, they are also hypothetical constructs. Perhaps, though, observable behaviour could have been observed and measured before and after the implementation of PT, and as long as confounding variables were accounted for, it could have then been determined if PT focusing on sight word recognition demonstrated contingency adduction to more socially appropriate behaviours.

There is evidence to suggest that PT in a particular skill area not only improves that skill but that the newly acquired skill can be successfully applied to novel situations and that sometimes entirely new behaviours that have not been directly taught can emerge as a result of the PT method. The degree to which the skills learnt through PT are applied in other areas or adduct into new behaviours, however, depends on the level of frequency obtained during PT (Binder, 1996). The higher the level of accurate responding during PT, the greater the probability of the

newly learnt behaviour being applied to other areas of the person's life and also potentially leading to new behaviours. The purpose of the present study is to use PT to improve the participants' fluency in sight word recognition and multiplication, but to also examine if this had any effect on other classroom activities and behaviour i.e. are application and adduction demonstrated. A multiple-baseline and multiple-probe design was used with two dyads, and due to the nature of the school and participants, as well as time constraints, the rationale for the procedure used is outlined below.

Rationale for Procedure

Multiple-baseline and multiple-probe designs are considered to be appropriate methods to use in educational settings, as not only can it be unethical to reverse an intervention, it is also unlikely that a skill can be unlearnt once it has been acquired, rendering the withdrawal design unsuitable in such environments (Murphy & Bryan, 1980). Initially baseline data is collected for all the settings, subjects, or behaviours in the experiment and, following the stabilisation of these baselines, the experimental variable is implemented for one setting, subject or behaviour (Barlow, Nock, & Hersen, 2009; Murphy & Bryan, 1980). When a steady change is evident in this condition, and baseline conditions have remained stable in the other conditions, the intervention is applied to the next setting, subject or behaviour and so on (Barlow et al., 2009; Murphy & Bryan, 1980). The effectiveness of an intervention is demonstrated if change only occurs following the introduction of the treatment variable in each condition, and until this point behaviour has remained stable (Barlow et al., 2009; Murphy & Bryan, 1980). The replication of the effects of the intervention in each condition reduces the possibility of other factors that may have occurred over time contributing to the change in behaviour (Barlow et al., 2009; Murphy & Bryan,

1980). In this study, there are two dyads and if similar effects are evident in both groups it adds further support to any changes in performance being due to the intervention. In some situations, it is not feasible to continuously measure a baseline though and as such a variant of the multiple-baseline design, a multiple-probe design, may be more useful, as measurement of baseline behaviour occurs at intermittent points in time (Barlow et al., 2009; Murphy & Bryan, 1980).

In this study, a combination of multiple-baseline and multiple-probe designs were used in the sense that whilst establishing an initial baseline, data was collected continuously however once the intervention was implemented for one participant, the baseline for the other participant was only probed. This decision was made because children diagnosed with ADHD tend to require high levels of positive feedback (Zentall, 2005) therefore monitoring a baseline condition in which failure is repeatedly endured in order to maintain a steady baseline is not appropriate. Also, issues of reactivity may arise where "an intervention must be powerful enough not only to improve a particular behaviour but also to overcome any extinction, boredom, fatigue, increased competing behaviour, or other undesirable effects introduced through the use of extended baselines" (Murphy & Bryan, 1980, p. 330), factors that are likely to be potential problems of an intervention aimed at students with ADHD. A multiple-probe design is therefore considered to be more appropriate than a multiple-baseline design in such a setting, as probes only occur infrequently during the experiment (Murphy & Bryan, 1980), therefore the instances where the student may fail are few and far between and issues of reactivity are minimised. If the behaviour occurring at the time each probe is administered is similar to the behaviour evident during the previous probe, then it indicates that there has been no change in behaviour due to other variables over time and that the change in behaviour exhibited

following the intervention with the first participant can, in fact, be attributed to the experimental variable (Barlow et al., 2009). A replication of this change in behaviour following the experimental variable being introduced with the second participant further supports that the change is due to the intervention (Barlow et al., 2009). A further reason for the use of multiple-probe designs in educational settings is that there is a high probability of baselines remaining stable, without needing to specifically measure them, due to "changes in skill level usually occur[ing] only during and after some instructional procedure" (Murphy & Bryan, 1980, p. 330). Based on the above reasons, it appears that, following the establishment of an initial baseline, occasional probing, rather than continuous measurement, is the most suitable method for collecting the data for this experiment.

Initially, once performance criteria was met for each target skill, the sight word group was going to be taught multiplication and the multiplication group taught sight words. Some baseline data was intermittently collected for these other skills during the phase of the first skill, however due to time constraints and the loss of two participants from the experiment, this part of the study was omitted. Arguably it would have added to the validity of the study, however if improvements in the target skill are only evident following the implementation of PT for each participant then it can be argued that the changes are due to the intervention. If this is seen with the participants in Groups A and B then the effects of PT are evident four times thus increasing the validity of the study. Also, any changes in the measures of assessing the effectiveness of PT in other classroom activities and behaviour can be said to be due to PT if changes in these measures only occurred following the implementation of PT with all four participants.

Previous published research also supports the validity of using a multiple-baseline design consisting of only one or two dyads. For example, Hartnedy et al. (2005) conducted PT in maths skills with two participants using a multiple baseline across individuals design and reported that the improvements obtained in the participant's target skills were due to PT. The strength of the validity of this current study is therefore twice as strong as this published study as it contains two multiple-baseline designs with two participants in each group. Furthermore, a study by (Lancioni et al., 2008) used two multiple-probe designs across participants to assess the effectiveness of prompting in the ability of the participants to perform various activities within a room and it was reported that, following the intervention phase, all four participants were able to perform the required activities. As this is another published study, it further substantiates the validity of using a two dyad multiple-baseline/multiple-probe design for the current experiment, as if changes in behaviour can be said to have occurred following the intervention phase only, and this is evident with four participants, then it can reliably indicate that the change is due to the intervention.

At the outset of this study, the aim was to collect data on a daily basis however, due to the nature of the school, on average, data was only collected three days a week. This was due to being advised not to go on a Friday, as class time was minimal, and often the class would have gone on an outing or the participants were absent from class. Data was therefore collected as continuously as possible, given the circumstances.

Method

Participants

All of the participants had diagnoses of ADHD but they are all also representative of broader antisocial challenges, as they attended the Kauri Centre, a specialised school in Hamilton where this study was conducted, because they had been excluded from mainstream schools due to their severe problematic behaviour and criminal records. Initially four boys participated in the study and they were split into two groups with a different target skill being taught to each group. The split was based on age with the first group consisting of two boys aged six (P1) and eight (P2) at the beginning of the study. The members in this group remained the same for the duration of the study. The second group initially consisted of two boys aged 11 (Initial P3) and 13 (Initial P4), however after four weeks of collecting baseline data with Initial P4 he left the Kauri Centre and after eight weeks of firstly collecting baseline data and then administering PT with Initial P3, he also left the Kauri Centre. Consent therefore had to be obtained for two other students in the classroom to participate in the study, these being one boy aged 12 (P3) and one girl aged 10 (P4). These two participants were involved in the remainder of the study. The University of Waikato Ethics Committee and the principle of the school approved this project and it was only once an official consent form (refer to Appendix A) had been signed by each of the participant's parent or guardian that research began.

Materials

Each participant had a set of SAFMEDS cards; SAFMEDS stands for "Say All Fast, Minute Each Day, Shuffled" (Precision Teaching Hub, 2008). This idea was developed by Dr Ogden Lindsley during the 1970's and 1980's and is based on

learning a deck of cards by practicing the terms on the cards and then saying out loud as many of the terms as possible during a one-minute time period (Precision Teaching Hub, 2008). The cards are shuffled each day and if an answer cannot be said quickly upon presentation of the card then it is counted as incorrect and the next card is moved onto (Precision Teaching Hub, 2008). A smaller group of cards can be used to begin with and the timing is adjusted accordingly. More cards are added once the previous cards can be said quickly and accurately and the timing increases in accordance with the number of cards in the pile (Precision Teaching Hub, 2008).

For Group A, each card contained a single word and these words were obtained from the appropriate level of the Dolch Sight Word List (Lanternfish Language Arts, 2007; refer to Appendix B). This was based on matching the levels of the Dolch Sight Word List as closely as possible to a list of words the teacher had previously identified as being at the level of each child's reading and spelling ability. Subsequently, the SAFMEDS cards for P1 consisted of 40 words from the preprimer Dolch Sight Word List and 10 words from the primer level. P2's SAFMEDS cards were 52 words from the primer level of the Dolch Sight Word List. An informal preliminary test of these words was conducted to ensure that the participants did not know the majority of these words. The SAFMEDS cards for Group B consisted of multiplication sums on one side of the card and the answer on the other side. Based on a preliminary run through of the 1 - 10 times tables, it was decided to include only the 1 - 5 times tables, with factors ranging from 1 to 10, for P4, and the 1 - 10 times tables, with factors ranging from 1 to 10, for P3. Data was collected on paper-based Standard Celeration Charts and daily recording sheets.

Various other measures were also tested using one-minute timings, with a summary of the number of correct and incorrect responses recorded on paper and

electronically. A number of materials were required for these measures and they are described as follows. For Group A, various 'readers,' at the level the teacher had stated was appropriate for each child, were used and these were accessed through class resources and various libraries (refer to Appendix C). Short picture books were also used and these too were borrowed from libraries (refer to Appendix D). Two exercise books were used to collect samples of the participants' handwriting. A probe sheet was also used when teaching the participant new words. For Group B, multiplication worksheets and division worksheets from The Math Worksheet site.com (n.d.) were used (refer to Appendices E, F, G and H). Worksheets with word problems involving multiplication were also used (refer to Appendices I and J).

Further materials that were required were a timer, ruler, pencils, and pens. Stickers were also used when specific performance goals were met. Two Palm Pilots were also used so as to record various behaviours that were observed during a session. One Palm Pilot was set up to record the targeted behaviours of the participants in Group A and the other Palm Pilot was used to record the behaviour of the participants in Group B.

Procedure

PT, using SAFMEDS cards, was administered to the first participant in each group following the establishment of a stable baseline for both participants. Once a steady increase was evident in the rate and accuracy of responding for the first participant in each group, PT in the targeted skill was implemented for the second participant. The target skill being taught to Group A was sight word recognition and multiplication was taught to Group B.

Baseline phase.

Baseline data was collected on as close to a daily basis as possible, and was done so as follows:

- SAFMEDS cards containing words for Group A and sums for Group B were presented to the participants and the number they got correct and incorrect in one-minute was recorded on a daily recording chart without the participant knowing the results. Any cards that were skipped i.e. the participant said “I don’t know”, were counted as incorrects.
- Group A was then given a book to read and timed for one-minute. The number of correct and incorrect words read was recorded. Incorrect words included those that were skipped. They were then read a short picture book and given one minute to verbally recall as much information as they could remember with the number of correct and incorrect facts being recorded. Finally, they were given a passage of writing to copy and how much of it they were able to copy within one minute, along with accuracy, was recorded.
- Group B were given three different worksheets to complete as much of as they could within a one-minute time frame, and the number they got correct and incorrect was recorded. The first worksheet consisted of multiplication sums (1 - 10 times tables for P3 and 1 - 5 times tables for P4). The second worksheet contained division problems with quotients of 1 - 10 for P3 and 1 - 5 for P4. Sheets with word problems based on multiplication were then given to each participant and the problems were read to them and the number of correct and incorrect answers they wrote in one-minute was recorded.

Four weeks after starting to collect data, baseline was established for the target skill for each of the four initial participants. Due to absentees and days when the class were away, this consisted of eight baseline sessions for P1 and nine baseline sessions for Initial P3 before PT was administered to these two participants. During these initial four weeks, five sessions of baseline data were obtained for P2 and seven sessions of baseline data were collected for Initial P4. From this point on, baseline was only probed for these two participants, with seven further sessions of baseline data collected for P2. Data was only obtained from one such session, however, for Initial P4 before he left the Kauri Centre. After five sessions of PT with Initial P3, he also no longer attended the Kauri Centre. Data collection for the second dyad was therefore postponed for six weeks, as it took this long to recruit and obtain consent for two new participants, plus within this period there was a two week school holiday break and a further week when data was unable to be collected due to being asked to give a new teacher time to settle into the classroom before proceeding with the research.

Over the course of two weeks baseline data was collected for the two new participants in the second dyad, at which time baseline was shown to be stable after eight sessions for P3 and seven sessions for P4. PT was subsequently administered to P3. As with the first dyad, baseline was probed with P4 from this point on, with a further three sessions of baseline data collected. Each time a probe was administered to P2 and P4, the results were similar to each previous probe therefore baseline can be said to have remained stable without having to continuously measure it whilst PT was being administered to P1 and P3. Likewise, the participants that were being taught their target skill using PT were only probed with the other measures i.e the worksheets and books etc, on alternate sessions.

Intervention phase.

During the intervention phase, the same data was collected as during the baseline phase, however the participants were told the number of correct and incorrect responses they obtained with the SAFMEDS cards. They were then taught how to record this on their daily recording sheet and plot it on their Standard Celeration Chart. The participants were also sometimes given stickers as an added reinforcement for meeting daily goals. The target skill was taught by way of rate building, and based on what appeared to be a common aim set in previous studies (e.g. Downer, 2007; Fabrizio & Moors, 2003; Hartnedy et al., 2005), performance aims were initially set at 50 words or sums correct per minute, with three or less incorrect responses. The criteria for incorrect responses remained the same for all the participants, however the number of correct responses per minute were adjusted according to the ability of each participant with the following performance aims being set: 35-40 for P1, 40-45 for P2, 50 or more for P3, and 30-35 for P4. The rate building procedure is described below for each of the participants in both groups A and B, with timings adjusted according to the number of SAFMEDS cards being used in a session; the results were calculated to reflect the number of correct and incorrect responses that would have been obtained within a one-minute timing.

Group A.

P1.

Following the establishment of a stable baseline, there were five weeks left of the school term and during this time 12 sessions were conducted with P1 whereby the PT teaching method was used in an attempt to increase the speed and accuracy of the participant's recognition of words by sight. A few minutes to practice the words were provided before each timing and a probe sheet was sometimes used where the current

words being learnt were written two or three times and the participant would practice reading through the sheet. Some other techniques were also used to teach the new words, such as making up a short rhyme about the word e.g for 'that' - "that fat cat".

Initially, five cards were taught to P1 and as the speed and accuracy of responding to these cards increased to the point that at least 80% were said correctly and immediately upon presentation of each card, more cards were added and these words were then taught to the participant. Once the aforementioned performance criteria were met, more cards were added and so forth.

After three sessions with these initial five cards, one more card was added so six cards were used for the next two sessions. In the following session, one more card was going to be added, however P1 insisted in adding a further two cards of his choice. During this session P1 was making quite a few mistakes and it was thought that this was due to too many words being added at once and that two of the words that were added were similar to two existing words and as such P1 seemed to have difficulties differentiating between the various words. In the following session the two words that P1 added were removed and one further new word was added. After two sessions, performance criteria was met thus a further three cards were added. Performance criteria was met in one session therefore two more cards were added in the following session. P1 responded quickly and accurately to all these cards so two more cards were added for the next session.

At this point, the school term ended and there was a three-week break during which time no PT was administered. When PT began again, there was a decrease in P1's response rate, however after five sessions he returned to the performance level before the break. Following the sixth session, three more words were added and these 18 words were used for the next three sessions, at which point two more words were

added, as P1 was able to say all of the 18 previous words correctly within 30 seconds. These 20 cards remained the same for the next three sessions. Following this, two more cards were added and after two sessions, a further three cards were added. After three sessions using 25 cards, this increased to 28 cards being used and, as P1 got 27 of these cards correct in one-minute a further two cards were added in the following session. During this session P1 said all 30 cards correctly within one-minute so in the next session four more cards were added. In the next session, P1 said all these 34 cards correctly within one-minute therefore in the following session two more cards were added. P1 correctly responded to 34 of these 36 cards within one-minute. Time ran out before the remaining two cards could be presented and, because he was able to say these two words and the initial goal set for him was to be able to say 30 words in one-minute, two more cards were added in the following session. In this and the next session, during one-minute P1 was only able to say 21 of the 38 cards correctly and got 4 and 6 words wrong in each session respectively. Extra instruction was therefore provided in the next session in the form of helping him read some sentences that contained the words he seemed to be having difficulty with; he subsequently got 36 words right and only two wrong. These 38 cards remained for the next session, which was also the final session for the school term.

In the first three sessions conducted after a two-week break for the end-of-term school holidays, the same 38 cards as before the break were used. In the fourth session three more cards were added and these 41 cards remained the same for the following session, however two more cards were added in the next session. These 43 cards remained the same for the following session, with more three more cards being added in the next session and these 46 cards were used for the subsequent five sessions before one more card was added in the next session. In the following session

two more cards were added and these 49 cards were used for the next two sessions. During these two sessions, some extra practice was provided for differentiating between pairs of words P1 often mixed up. After this, the final card in the pack was added and two more sessions with 50 cards were conducted before PT ended and no more data was collected.

P2.

In a similar fashion as with P1, an opportunity for P2 to practice the words on his SAFMEDS cards was provided before conducting the timing for each PT session, and new words were only added if P2 responded with at least 80% accuracy. Initially five cards were used and, due to P2 saying all these words correctly within 10 seconds, a further six cards were added in the next session. In each of the next four sessions, two more cards were added, as P2 was responding with over 90% accuracy in a timeframe of 20-40 seconds. In the seventh session one more card was added and as P2 got three of these wrong, these same 20 cards were used in the next session. In this session, P2 said all the words correctly within 30 seconds so three more cards were added in the next session. P2 once again scored with 100% accuracy therefore two more cards were added in the following session. In this session, P2 got one of the 25 cards wrong but in the next session he got them all right in 40 seconds so two more cards were added in the next session. P2 got all 27 of these cards correct within 40 seconds therefore three more cards were added in the next session. P2 got two wrong so these 30 cards remained for the next session, during which he responded correctly to all of the cards within one-minute. Three more cards were added in the next session and, as P2 only got one of these wrong, two more cards were added in the following session. P2 was only able to say 25 correct, with five incorrect, in this session and 28 correct, with two incorrect, in the following session. Extra instruction was provided

during the next two sessions and this consisted of a probe sheet and helping P2 read sentences containing the words he seemed to be having difficulty with, resulting in him being able to say all 35 words correctly within one-minute during the last session of the school term.

In the first session after the holidays P2 got the same words wrong that he was struggling with at the end of the last term therefore these four words were removed and two new words were added in the next session. These 33 words were kept for the next session then in the following session one of the four previously removed words was returned to the set. In the next two sessions, one and then two more words were added respectively. These 37 cards were kept for the next three sessions, at which point two more words were added. In the following session, one more word was added and these 40 words remained the same for the next two sessions, with one more word being added in the following session. In each of the next three sessions, one more word was added. These 44 words remained the same for the next session, however in the following session one more word was added. These 45 words were then used in the final three sessions conducted before PT ended.

Group B.

For the multiplication group, one set of times tables was taught at a time, starting with the one times tables and moving up in a hierarchical fashion once the previous sums were learnt. The number of sums within a set to be taught at once depended on the ability of the participant. Further cards were only added once the current cards could be said quickly and accurately. These cards were taught through repetition and if any rhymed e.g. 6 x 8 = 48, then this was told to the participant. The participants had a few minutes practicing the cards before the one-minute timing was conducted for each day.

Initial P3.

Following the establishment of a steady baseline, PT was administered to Initial P3 for five sessions before he left the Kauri Centre. Teaching began by focusing on the one and two times tables. In the first session, Initial P3 responded correctly to all 20 cards and did so in 40 seconds. This score was converted to reflect the number of responses that would have been emitted in a one-minute timing. In the following session seven cards were added, these being from the three times tables with factors ranging from one to seven. These cards remained the same over the next four sessions, as Initial P3 attempted to increase the number of correct responses each session. During this period, Initial P3's performance on the multiplication, division, and word problem worksheets was measured in two sessions.

P3.

A run through of the one times tables with P3 showed that this participant was able to say all of these answers quickly and accurately. The two times tables were therefore added to the set of cards being taught and an initial attempt at these showed that P3 knew some but not all of these times tables. P3 practiced these cards and then a one-minute timing was conducted. The cards that P3 got incorrect were identified so that during the practice period in the following session emphasis was put on learning these cards. By the fourth session, P3 was able to say 19 of the 20 cards correctly within 40 seconds. Over the next three sessions, the cards 3 x 1 through to 3 x 6 were systematically added two cards at a time, as P3 was responding correctly to all the cards presented to him during each one-minute timing. In the ninth session, the remaining four cards in the three times tables were added and as the respondent got over 90% correct within one-minute, the first three cards in the four times tables were added to the next session. These 33 cards remained for the following session and,

since P3 got them all correct within one-minute, the next three cards in the four times tables were added to the next session. P3 got all of these 36 cards correct within one-minute so the remaining four cards in the four times tables were added in the next session and, once again, P3 responded correctly to all the cards within one-minute. All of the five times tables were added in the next session and these 50 cards remained for the following session, during which P3 said 45 of these cards correctly, getting none wrong, within one-minute. The initial goal was to be able to say between 45 and 50 answers correctly within one-minute and he could also say the answers to the remaining five cards therefore the first five cards of the six times tables were added to the next session. These 55 cards remained for the following session, at which point P3 answered 50 sums correctly within one-minute so the next two cards in the six times tables were added to the next session. After three sessions with these 57 cards, the last three cards were added and during this session P3 obtained 52 correct responses, and no errors, within one-minute. This was the last session of the school term.

These cards remained the same for the first three sessions following the two-week school holiday break, then the first two cards of the seven times tables were introduced in the fourth session, with 7 x 3 being added in the next session. These 63 cards were used for the following three sessions, at which point two more cards were added. After the following session two more cards were added and these 67 cards were also used in the next session. In the following session, however, the last three cards in the seven times tables were added and these 70 cards remained the same for the next session, at which point the first two cards of the eight times tables were added. After two more sessions using these 72 cards the next three cards in the eight times tables were added. Four more sessions using these 75 cards were administered before PT ended.

P4.

The one times tables were taught to P4 in the first PT session, along with the first four cards of the two times tables. In the second session P4 responded with 100% accuracy within 30 seconds therefore the cards 2 x 5 and 2 x 6 were added in the next session. P4 responded with over 90% accuracy within 30 seconds in this and the following session therefore the remaining cards in the two times tables were added in the fifth session. All 20 cards were said correctly within 40 seconds therefore the first three cards of the three times tables were added in the next session. In the following three sessions, P4 responded below the criteria set for adding more cards so extra instruction was provided in the next session whereby the logic behind multiplication was explained and some examples were worked through together. P4 got all 23 cards correct within one-minute in this session. In the following session, the next two cards in the three times tables were added and, as P4 got all these correct within one-minute, three more cards were added in the next session. P4 got all 28 cards correct within one-minute however it was discovered that during the last two or three sessions she had been cheating by reading the answers on the back of the card through the card, as she was holding them into the light. I presented the cards during the timing for the next session and placed each card on the table so that she could not see the answer and she only got 17 correct, with three errors, within one-minute. In the following session, I removed five cards from the set, these being 3 x 4 through to 3 x 8 and I continued to present the cards to her during the timings for the remainder of the study. P4 got all 23 cards correct during this session so the next three cards in the three times tables were added for the next session. These 26 cards remained for the following session and P4 obtained 25 correct responses and one incorrect response within one-minute. This was the final session for the school term.

The same cards were used for the first three sessions after the school holidays, with the remaining four cards in the three times tables being added in the fourth session. Some extra instruction was provided for these cards in the form of illustrating what three groups of seven, eight, and nine looked like. These same 30 cards were used for the next nine sessions, at which point 4 x 1 was added and in the next session 4 x 2 and 4 x 3 were also added. After three more sessions using these 33 cards the next two cards in the four times tables were added. These 35 cards were used for the last four sessions conducted before PT ended.

Observation.

A further aspect of this experiment was observing various behaviours of the participants during both the baseline and intervention phases. The purpose of this was to determine if any changes in classroom behaviour unrelated to the skill being taught through PT occurred due to the PT process. The behaviours that were being observed were any off-task behaviour, any aggressive behaviour, and the number of times an instruction was given before it was followed, along with the latency between the instruction being given and followed. Off-task behaviour was defined as any behaviour that occurred besides the task the student should have been doing, apart from things such as chewing their pen or staring into space when they should be writing, as they may have been thinking about their work. Some examples of off-task behaviour include walking around the classroom when they should be sitting at the table, talking when they should be working silently, and drawing pictures on their workbooks when they should be doing the work set for them. The operational definition of aggressive behaviour included pushing or pulling another person, hitting, punching or kicking another person or object, and throwing objects. Instructions were

defined as any that were given during the observation period, by either the teacher or her assistant, excluding those related to the specific details of tasks. This definition includes instructions directed at the whole class and generally takes the form of the following examples: come here, sit down, sit still, put…….back, get……., be quiet/stop talking, do your work, or being told to do a specific task. An instruction was considered to be followed when the desired behaviour occurred, even if other behaviours occurred first i.e. even if the instruction was not directly followed. If the instruction had not been followed after two minutes, the instruction button was switched off and it was noted that the instruction was not followed. Likewise, it was noted if another instruction was given to the participant before a previous instruction had been followed.

The behaviours were observed using two Palm Pilots with the identified behaviours of the two participants in Group A being recorded on one Palm Pilot and the two participants in Group B being recorded on the other Palm Pilot. Observation was made on a daily basis providing the participants were in class and initially all four participants were observed at once, however this proved too difficult to ascertain accurate recording therefore it was decided that each group was to be observed on alternate days. Each session lasted for 15 minutes and was conducted when I first arrived in the classroom each day and this was usually just after class had started each morning.

Results

PT – Sight Word Recognition and Multiplication

P1 and P2 were presented with a set of SAFMEDS cards containing words. Figure 1 shows the number of words they each said correctly and incorrectly within one-minute. Similarly, P3 and P4 were presented with a set of SAFMEDS cards containing multiplication sums and Figure 2 shows the number they each answered correctly and incorrectly within one-minute. Figures 1 and 2 show that across all the participants correct responses increased and incorrect responses decreased following the implementation of PT. No trends are evident during the baseline phase for each participant and, with the exception of one score greater than 10 by P3, there were less than 10 correct responses each session during this phase. P4 gave the least number of correct responses, never responding correctly more than twice in one session. P1, P2 and P4 responded incorrectly much more than correctly during the baseline phase, with P1 and P2 incorrectly responding between approximately 15 and 30 times per session, and P4 responding incorrectly between 9 and 19 times per session. P3, however, usually got between 5 and 10 answers both correct and incorrect during each session. The collection of baseline data for P1 and P3 was continuous and this was also the case for the first few baseline sessions for P2 and P4 however, as the baseline phase was longer for these participants, data was collected intermittently for the remaining baseline sessions. The results show that correct and incorrect responses remained relatively similar throughout both baseline phases for P2 and P4.

Figure 1 shows that P2 showed a dramatic increase in rate instantly following the onset of the intervention, whereas P1's rate increased more slowly. In the first PT session, P1 gave 9 correct responses and an upward trend continued, reaching a maximum of 39 correct responses by the end of the school term. No data was

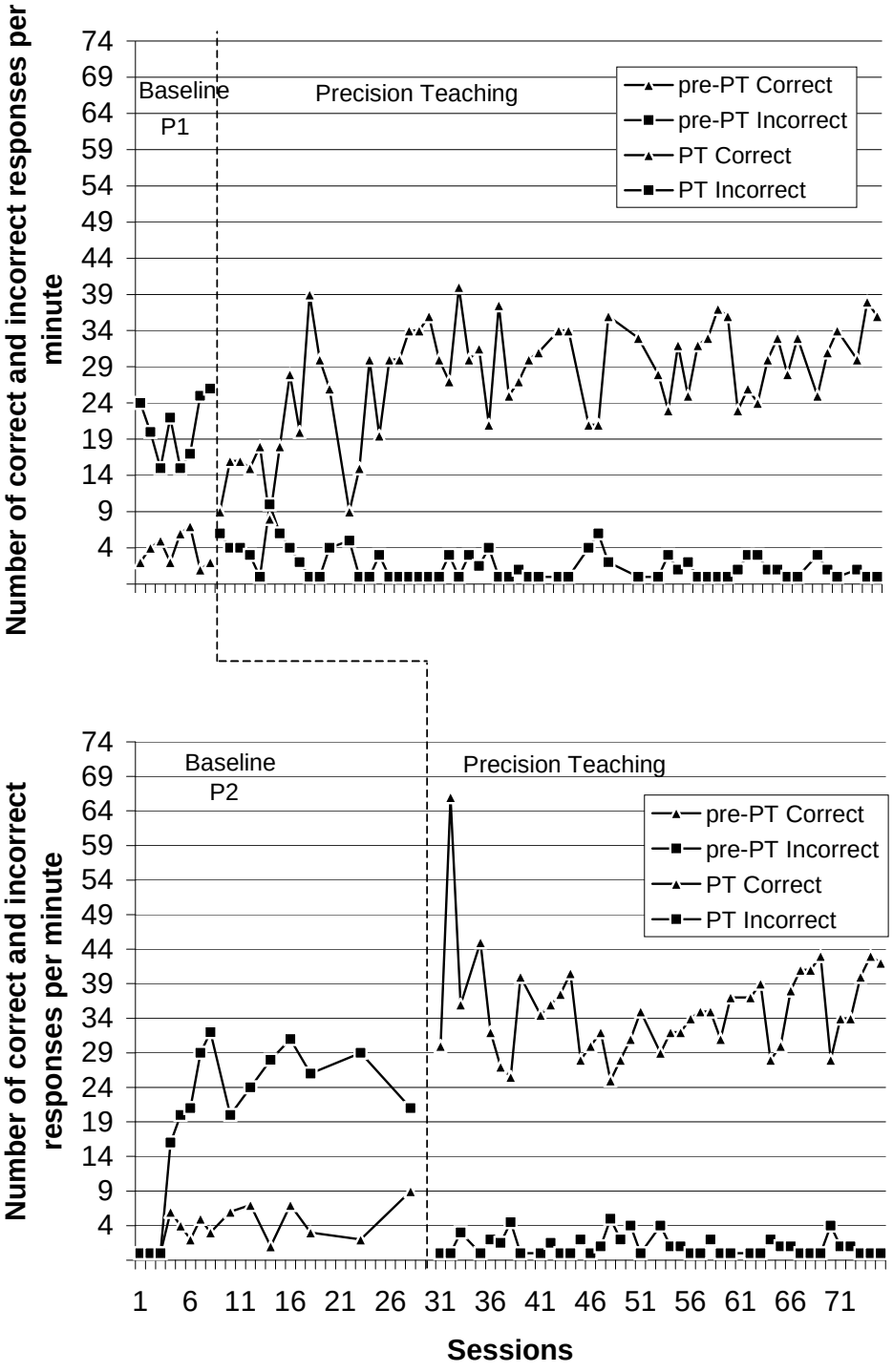

Figure 1. The number of words P1 and P2 got correct and incorrect, each session, during a one-minute timing of saying words presented on a set of SAFMEDS cards (the first three data points for P2 are actually missing data).

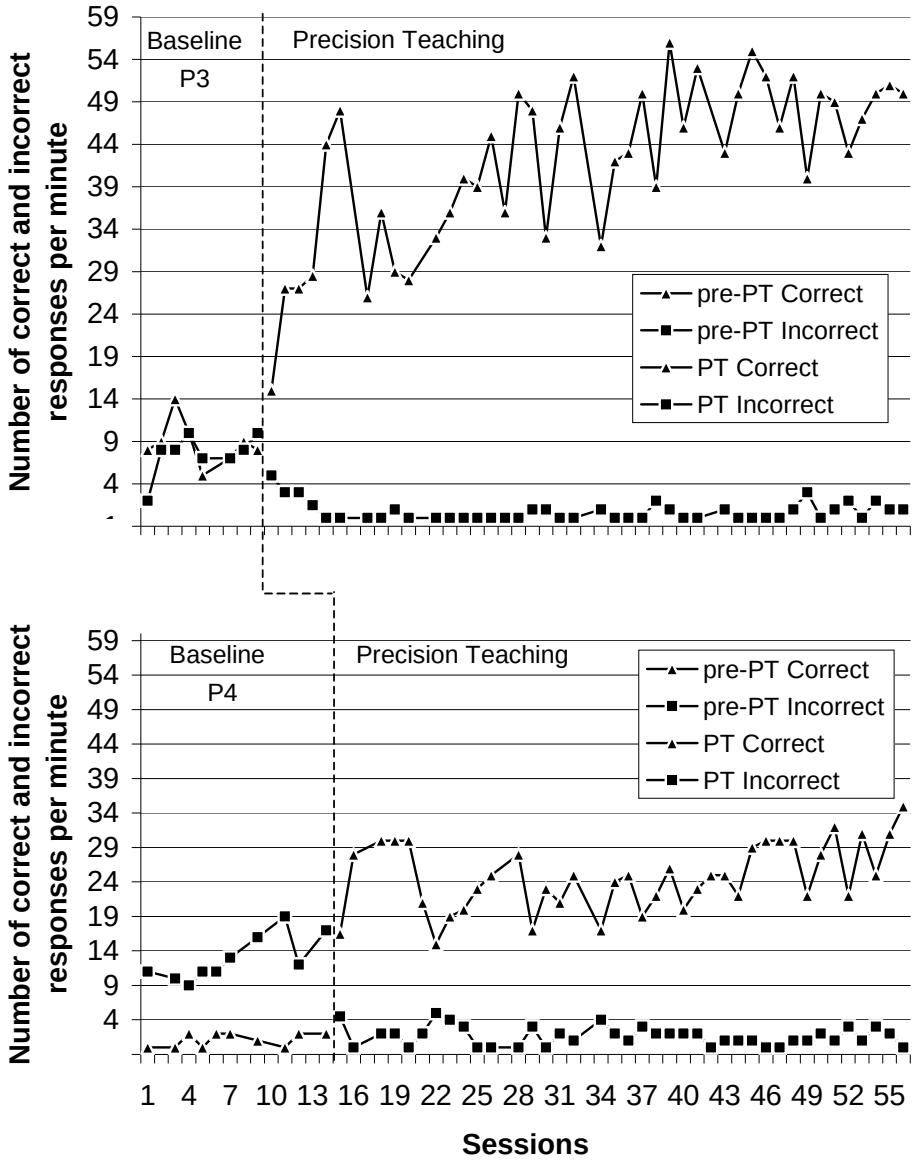

Figure 2. The number of sums, presented on a set of SAFMEDS cards, that P3 and P4 got correct and incorrect during a one-minute timing conducted each session.

collected over the school holidays and upon the return to PT the number of correct responses dropped back to nine. This then, however, began to steadily increase again before returning to the rate reached before the holidays. At this point there seemed to be no trend evident with the number of correct responses randomly varying between 20 and 40 over the remaining sessions. P2, on the other hand, got between approximately 25 and 45 words correct, non-systematically, over approximately the first 10 sessions and then over the remaining sessions showed a steady upward trend reaching a high point of 43.

Figure 2 shows that, with the exception of the first PT session for P3, both P3 and P4 showed an instant dramatic increase in correct responses once PT had begun, similar to P2. This upward trend continued for P3, reaching a high point of 52 by the end of the school term. Following the holidays, just like with P1, there was a decrease to 32 correct responses however a steady upward trend was then evident, reaching a high point of 56 correct responses in the sixth session after the break, at which point the scores varied non-systematically between 46 and 55 over the remaining sessions, with the exception of three slightly lower scores. Figure 2 also shows that P4's correct responses ranged between 15 and 30, with no trend evident, prior to the school holidays but, following a decline in the first session after the school holidays, an upward trend then began to emerge, reaching a high point of 35 in the final session.

Incorrect responses decreased for all participants following the implementation of PT with P1 and P2 showing the largest difference between the last score obtained in the baseline phase and the first score in the intervention phase, as can be seen in Figure 1. The number of incorrect responses varied non-systematically throughout the intervention phase and were similar for all the participants. P1 usually got between zero and six words wrong, P2 and P4 responded incorrectly between zero

and five times each session, and P3 got the answers wrong between zero and three times each session.

Overall, P1 and P2 went from being able to say less than 10, to approximately 40, words correctly per minute. P1 and P2 also went from getting 15 to 30, to usually less than five, words wrong per minute, often making no mistakes. P2 was able to respond accurately at a slightly higher rate than P1 however they both showed significant improvements in the number of words they were able to recognise by sight following the implementation of PT. Both P3 and P4 also showed an increase in the number of sums they answered correctly following the implementation of PT, however the rate of accurate responding was much higher by P3 than P4, and the slope of the line was also much steeper, indicating that P3 improved on rate and accuracy much quicker than P4. In fact, P3 responded at the fastest rate out of all the participants and P4 responded at the slowest rate. The baseline data shows, though, that P3 already knew more answers than P4. The number of new sums they were both able to answer correctly within one minute is comparable though, as accurate responding increased by about 30 and 40 sums per minute for P3 and P4 respectively.

Group B – initial participants.

As can be seen in Figure 3, over eight sessions of collecting baseline data for Initial P3, the number of correct responses to the sums presented on the SAFMEDS cards varied non-systematically between 7 and 13. During this period, the number of incorrect responses ranged between 10 and 20, with no trend evident. Following the establishment of this stable baseline, PT was implemented for five sessions before the participant left the Kauri Centre. Figure 3 shows that, with the exception of a score of

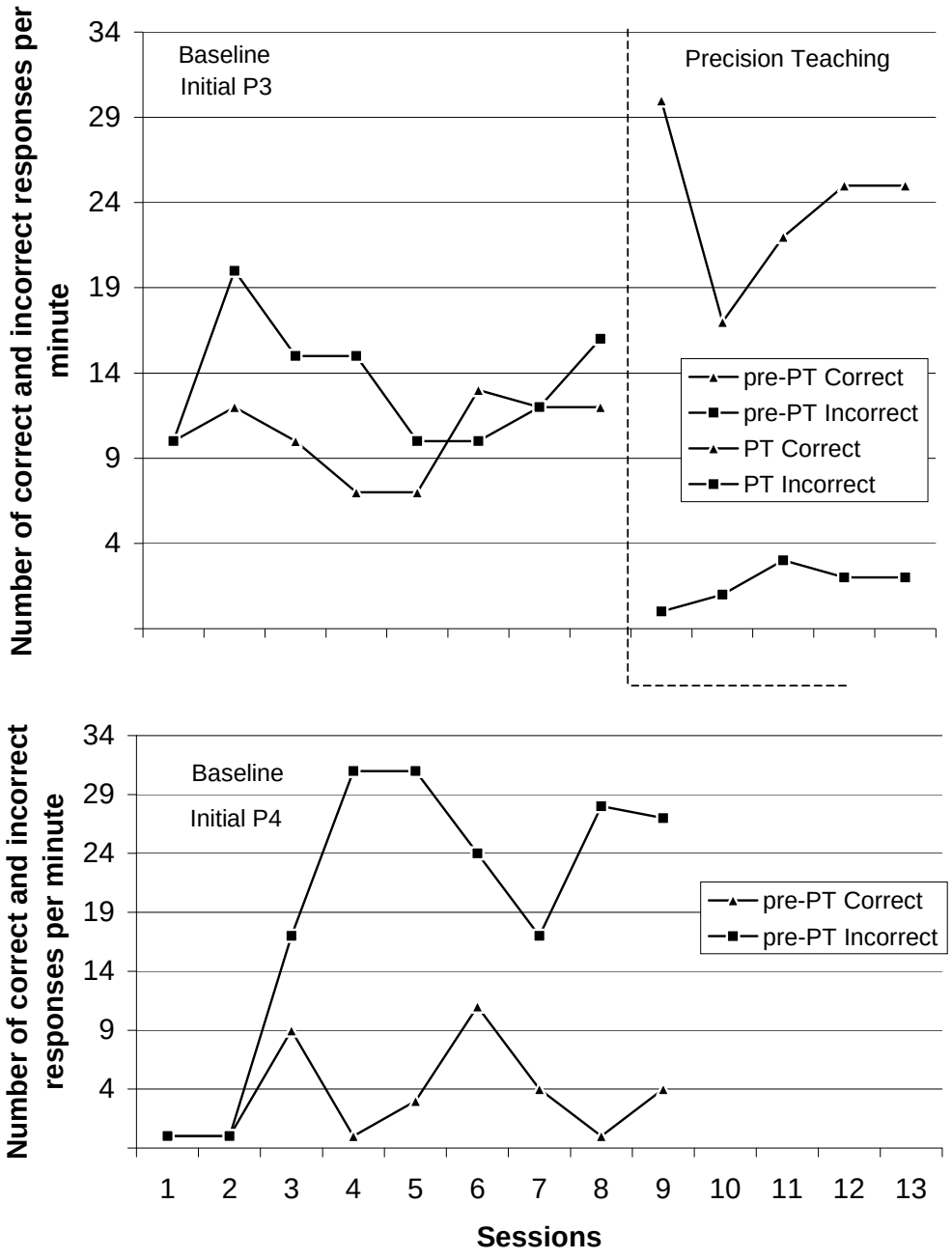

Figure 3. The number of sums, presented on a set of SAFMEDS cards, that Initial P3 and Initial P4 got correct and incorrect during a one-minute timing conducted each session (the first two data points for Initial P4 are actually missing data).

30 in the first session, there was an upward trend evident in the number of correct responses emitted, beginning at 17 and rising to 25. The number of incorrect responses decreased from those obtained during the baseline phase, with between zero and three incorrect responses randomly emitted during the PT phase. Baseline data was also collected for seven sessions for Initial P4, with the last of these sessions occurring whilst the intervention phase had begun for Initial P3. Figure 3 shows that the number of correct responses obtained during these baseline sessions ranged from 0 to 11, with no systematic trend evident. The number of incorrect responses during this phase varied non-systematically between 17 and 31. This initial data is comparable with the results obtained for the other participants, as no change was evident during the baseline phase, however after PT began, the number of correct responses increased and the number of incorrect responses decreased.

Other Measures

During both the baseline and PT phases, scores were obtained on other measures, these being reading, recall and writing for Group A, and multiplication, division and multiplication word problem worksheets for Group B. There was not enough data collected on these measures for the initial two participants of Group B to warrant analysing their results so they are omitted from this section. Reading and multiplication worksheets are thought to be the most closely related activities to the target skills of sight word recognition and multiplication so these results will be presented together, followed by the results for the other measures.

Reading and multiplication.

Figure 4 shows the number of words P1 and P2 read correctly and incorrectly in a school reader, and Figure 5 shows the number of answers P3 and P4 got correct and incorrect on a multiplication worksheet. It appears that there was some improvement on these measures for P1, P2 and P4, but not for P3.

The number of words read correctly and incorrectly during the baseline phase varied non-systematically for both participants, with correct responses ranging mostly between 9 and 32 for P1 and 14 and 22 for P2. During the intervention phase, P1 read between approximately 12 and 46 words correctly each session, with a few exceptions. Not only is this a slightly higher range than that obtained during baseline, a slight upward trend is evident. Following the implementation of PT, the number of words P2 read correctly steadily decreased to a minimum of 10, however there was then a sudden increase to 22 correct responses and for the remainder of the sessions, the scores varied non-systematically between 20 and 36, with the lowest score here comparable with the highest score during baseline. As can be seen in Figure 4, during the baseline phase the number of words read incorrectly by P1, with the exception of the first session, varied randomly between 3 and 18. During the intervention phase, once again with the exception of the first session, the number of incorrect responses initially increased from those obtained during baseline, however a downward trend was then evident and, with one exception, the scores varied between 0 and 12. The number of words read incorrectly by P2 during the baseline phase ranged between 12 and 36, with no systematic pattern evident. Although the range of words P2 read incorrectly during the intervention phase was rather similar to the data obtained for the baseline phase, ranging between 4 and 40, there appeared to be a slight downward trend evident.

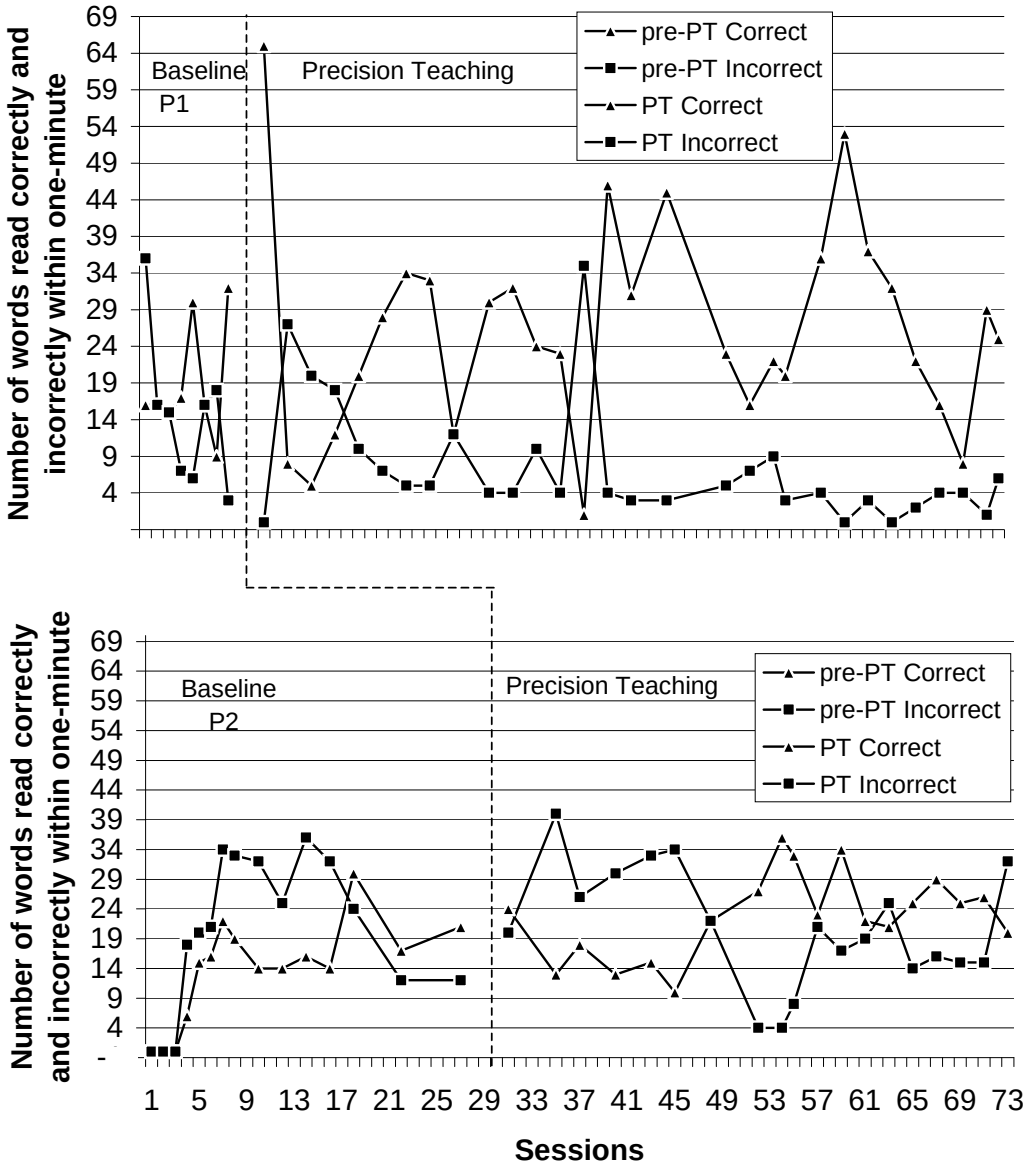

Figure 4. The number of words P1 and P2 in Group A got correct and incorrect during each one-minute session of reading from a school reader (the first three data points for P2 are actually missing data).

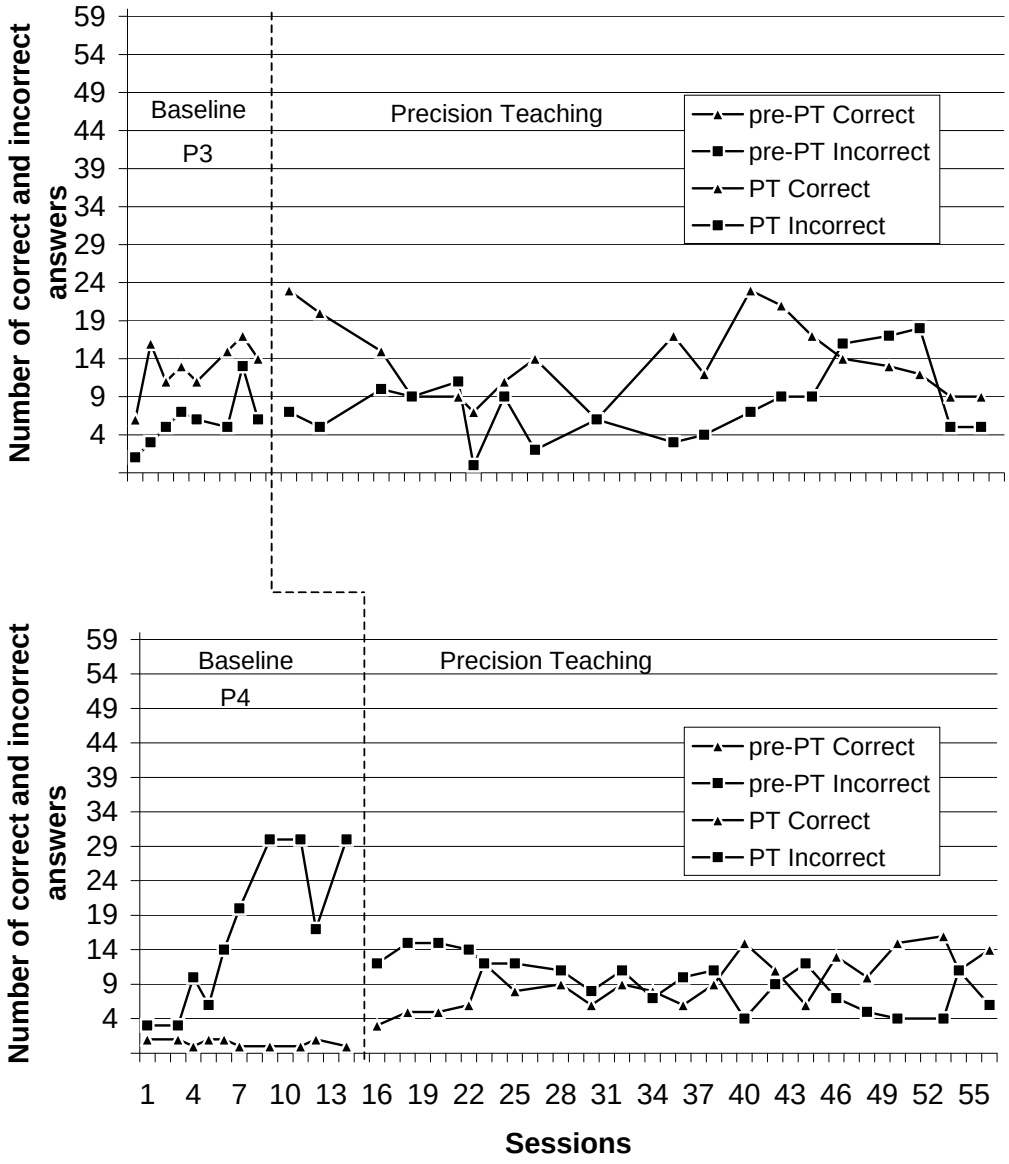

Figure 5. The number of correct and incorrect answers P3 and P4 gave on multiplication worksheets during a one-minute timing conducted each session.

The number of correct answers given by P3 on the multiplication worksheets did not seem to show any significant changes following the implementation of PT, however an upward trend was evident during the intervention phase for P4. There was also a downward trend evident after PT had begun for the number of wrong answers P4 gave on the multiplication worksheets whereas there was no trend evident for P3.

Figure 5 shows that, during the baseline phase, P3 consistently emitted more correct, than incorrect, responses on the multiplication worksheet, with the number of correct answers varying non-systematically between 11 and 16, with one exception. Following the implementation of PT, the number of correct answers initially increased from the baseline phase to 23, however the results then varied over the remaining sessions without any trends emerging. The number of incorrect responses appeared to be similar between both phases, varying between 1 and 13 in the baseline phase and 0 and 11 in the intervention phase, with a few exceptions.

Figure 5 also shows that, during both the continuous and intermittent measurement of the baseline, P4 consistently obtained either one or zero correct responses on the multiplication worksheets. During this phase, the number of incorrect responses showed an upward trend that began at three and rose to a maximum of 30. There was a decrease from 30 to 12 incorrect responses obtained following the intervention and a downward trend became evident, with four being the lowest score achieved. There were more correct responses given following PT than during baseline and these ranged between 3 and 16, with an upward trend evident.

The most steady increase in correct responses and decrease in incorrect responses was by P4, who also seemed to respond the least amount of times each session i.e. P4's response rate was the lowest yet she showed the most consistent improvement. The results during the intervention phase for P1 and P2 were rather

variable, however correct responses did appear to increase, and incorrect responses decrease, over time, although there was stronger evidence of this for P1 than P2. There was no systematic change evident following the implementation of PT for P3, but there was for P1, P2 and P4.

Recall and division.

P1 and P2 were also assessed on the number of correct or incorrect facts they could recall within one-minute following a story being read to them; the results can be seen in Figure 6. Figure 7 shows the number of right and wrong answers P3 and P4 gave on division worksheets within each one-minute session. A slight upward trend is evident for P1 and P4 following the implementation of PT, however there was no trend for P2 and P3 and the number of correct responses they gave were rather similar during both the baseline and intervention phases. P1's correct responses during baseline varied randomly whereas P4 gave no correct responses during this phase and only began to get some answers correct after PT had begun.

P1 and P2 usually recalled zero facts incorrectly, although sometimes they recalled one, and occasionally a few more, incorrectly, and this was the same during both the baseline and intervention phases. There was also not a clear change between phases for the number of incorrect answers P3 gave on the division worksheets. During the baseline phase and for the first few PT sessions there was a slight upward trend in P3's incorrect responding, but this then dropped and for the remaining sessions varied non-systematically within approximately the same range as during the baseline phase. P4, on the other hand, consistently gave 20 wrong answers during the baseline phase, with the exception of two scores of 30, but during the intervention

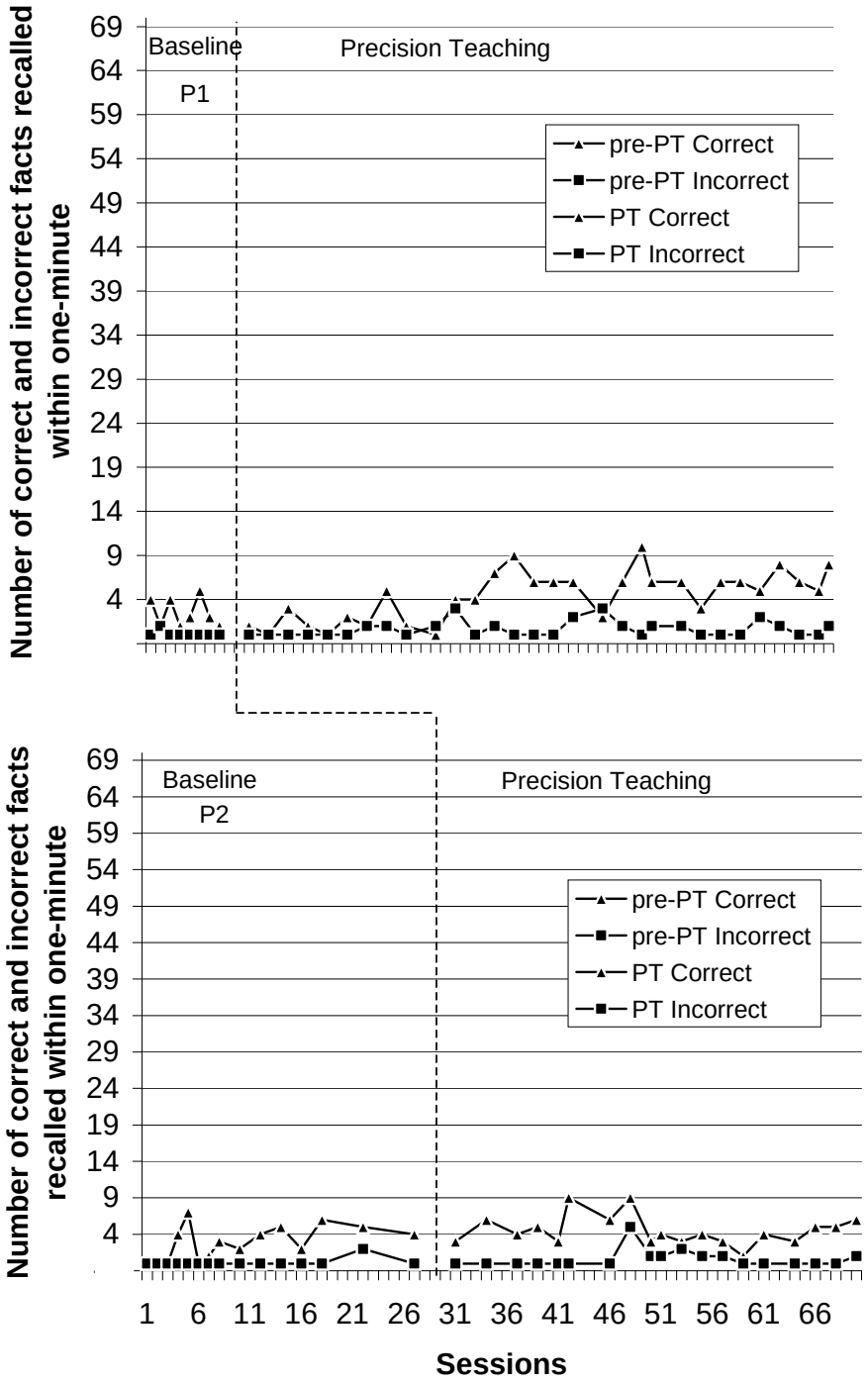

Figure 6. The number of correct and incorrect facts recalled, in a one-minute timing, by P1 and P2 after a short picture book was read to them (the first three data points for P2 are actually missing data).

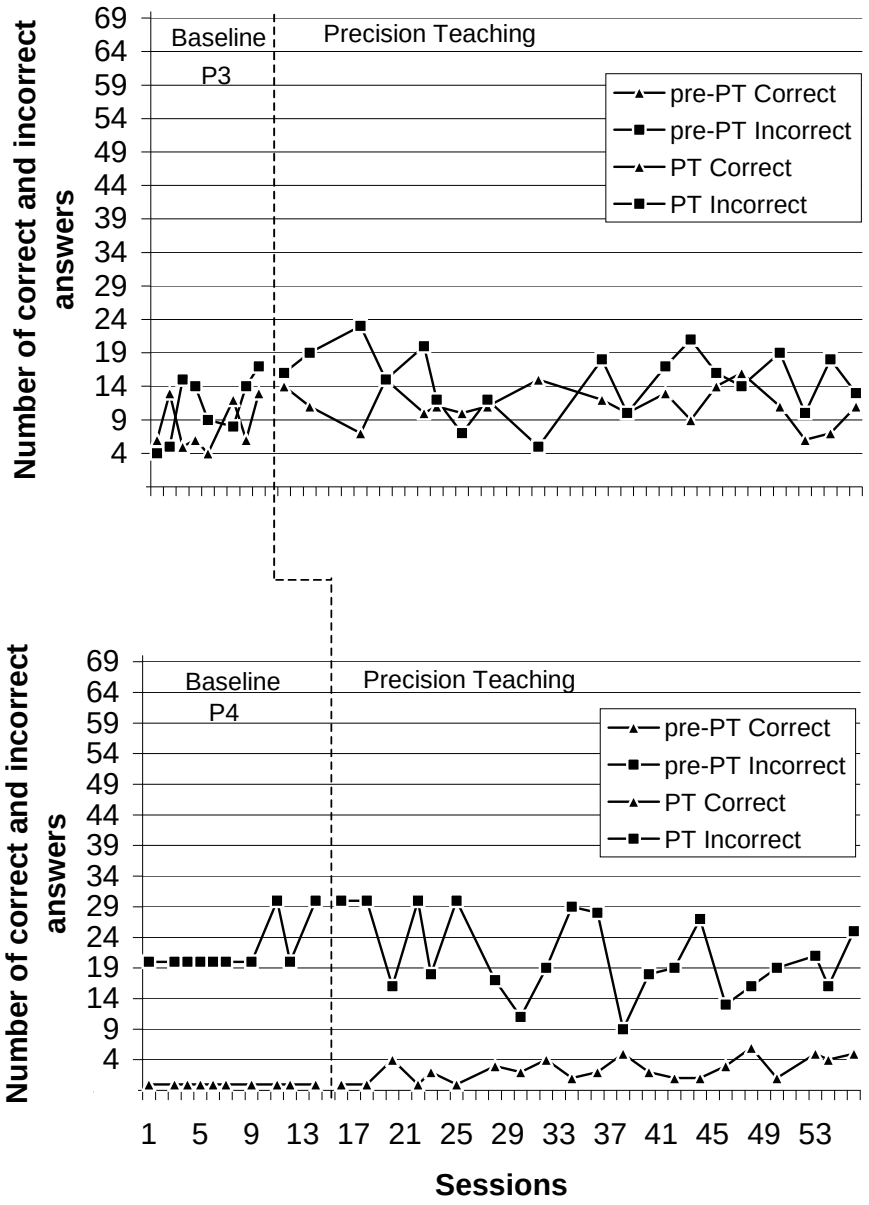

Figure 7. The number of correct and incorrect answers P3 and P4 gave on division worksheets during a one-minute timing conducted each session.

phase the incorrect responses showed no systematic pattern, varying mostly between 16 and 30. P4 was the only participant to show any change in incorrect responses following PT, however some of the lower incorrect scores were obtained in sessions where the overall response rate was lower. In comparison to the baseline phase though, P4 gave less wrong answers following the implementation of PT.

Handwriting and word problems.

Figure 8 shows the rate and accuracy of the letters written by P1 and P2 during each one-minute session, while Figure 9 shows the number of right and wrong answers P3 and P4 gave on word problem worksheets involving multiplication. There was more change evident on these measures following the intervention for Group A than Group B, however the change is not necessarily due to PT.

The handwriting samples were scored based on The Minnesota Handwriting Test (Feder & Majnemer, 2003), as described in full in Appendix K. During the baseline phase, the accuracy of P1's handwriting first decreased then increased and following an initial decrease from baseline at the start of the intervention phase, an upward trend, although rather variable, became evident. There was a slight downward trend evident for the rate of responses i.e. the number of letters P1 wrote in one-minute, however the majority of these scores fell within the same range that was obtained during baseline so there was not really much difference in rate following the implementation of PT. The main finding here is that as the rate decreased, P1's accuracy increased. During the baseline phase, both P2's rate and accuracy varied non-systematically, however during the intervention phase P2's rate steadily increased.

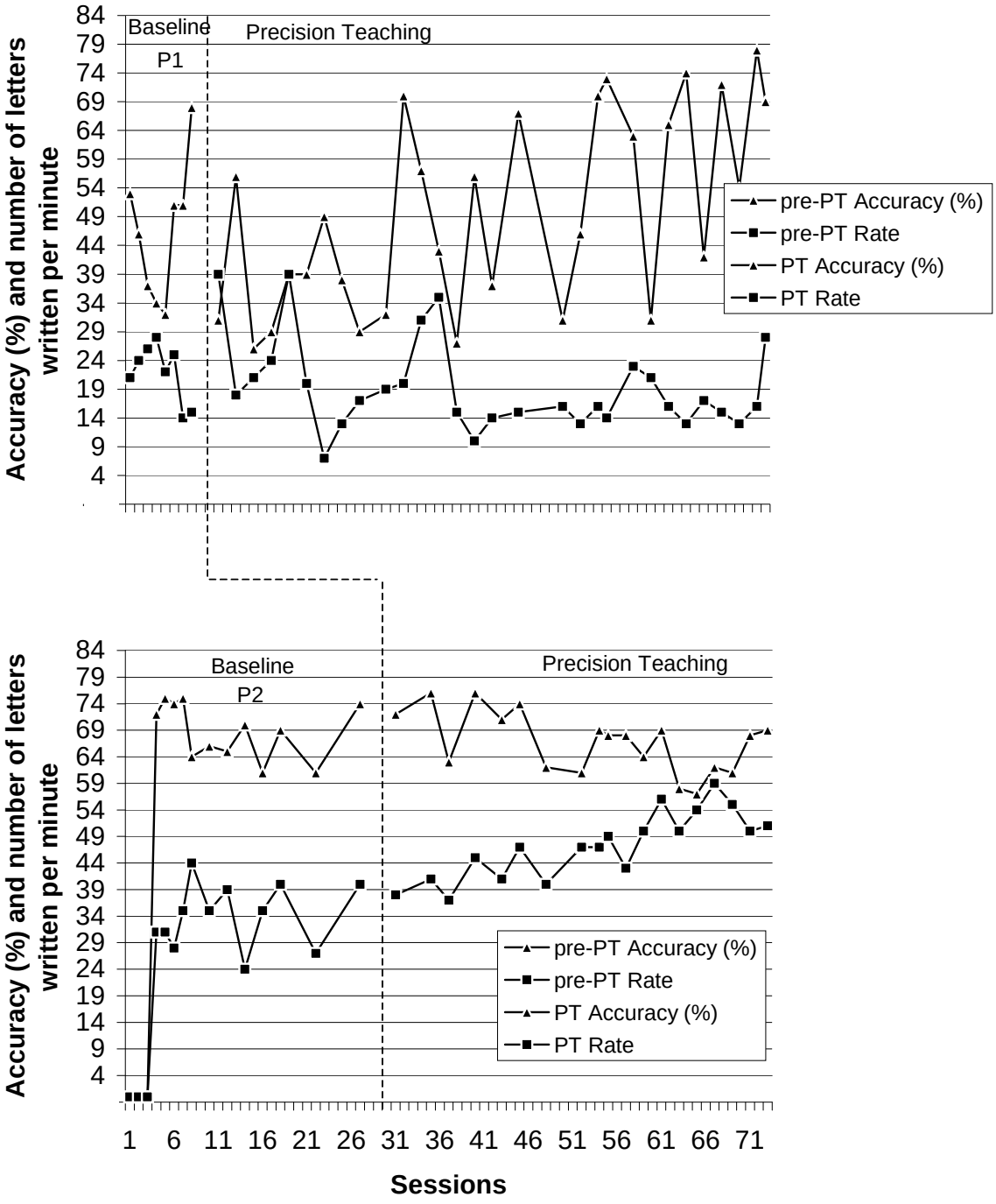

Figure 8. The accuracy and rate of letters written by P1 and P2 during each one-minute session (the first three data points for P2 are actually missing data).

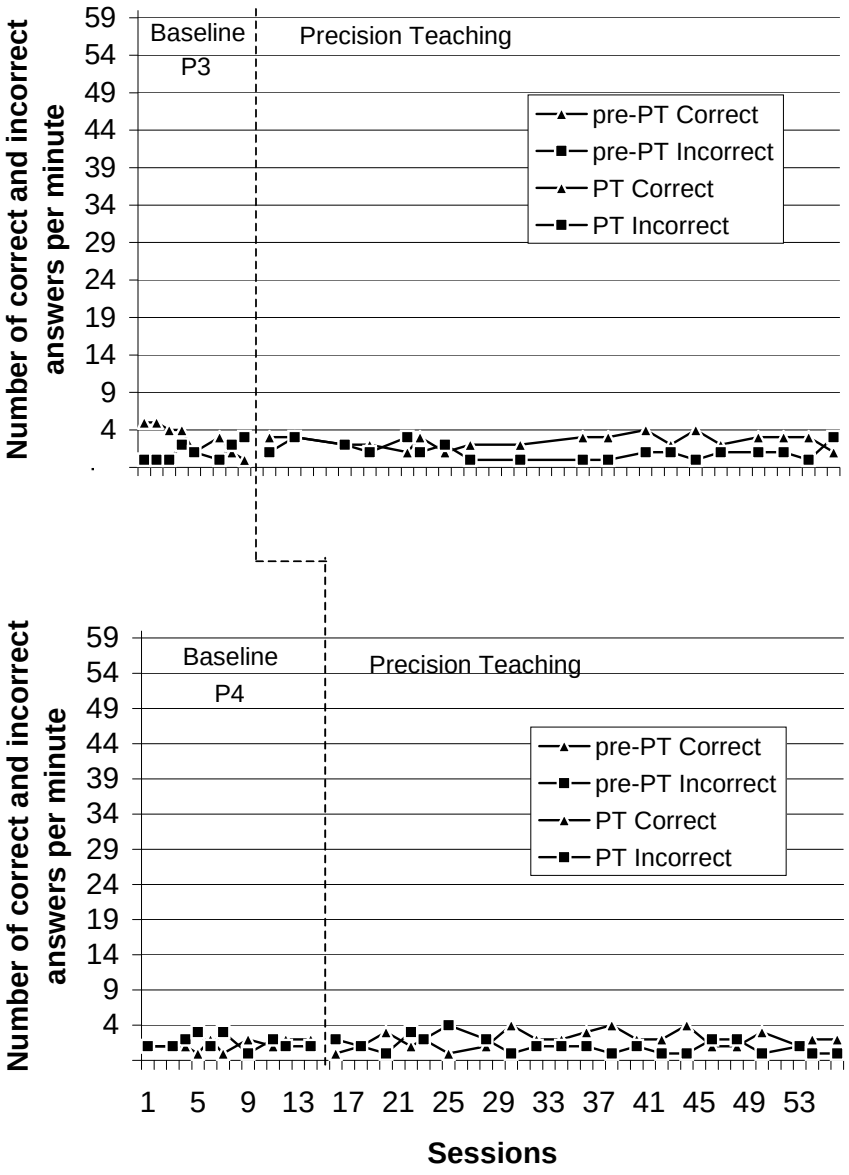

Figure 9. The number of correct and incorrect answers that P3 and P4 gave on word problem worksheets during a one-minute timing conducted each session.

In regards to accuracy, the range was rather similar during both the baseline and intervention phases, however a slight downward trend began to emerge during the intervention phase. It therefore appears that as the rate increased, P2's accuracy decreased. Figure 8 therefore shows that P1 seemed to show a slight increase in the accuracy of letter writing following PT but this corresponded with a decrease in rate, and the opposite occurred for P2, with accuracy decreasing and the rate increasing during the intervention phase.

As can be seen in Figure 9, there does not appear to be any change between the baseline and intervention phases for both P3 and P4 in terms of the right and wrong answers they gave on the word problem worksheets and the results for both participants appear to be rather similar. During the baseline phase, the number of answers P3 got correct decreased from five to zero, and P4 randomly got between zero and two answers right each session. Once PT began, there was not much change with P3 and P4 non-systematically getting between one and four, and zero and four, answers correct each session respectively. During both the baseline and intervention phases, with the exception of one session, both participants got between zero and three answers wrongs each session, with no trend evident. There was therefore no change in the answers given to word problems involving multiplication following the use of PT in the target skill of multiplication.

Observation

Figures 10 and 11 show the observation data that was recorded each session, both before and after PT had begun on the participants respective target skills. The behaviours that are depicted in Figures 10 and 11 are the time taken for each participant to respond to any instructions given, the number of instructions that were

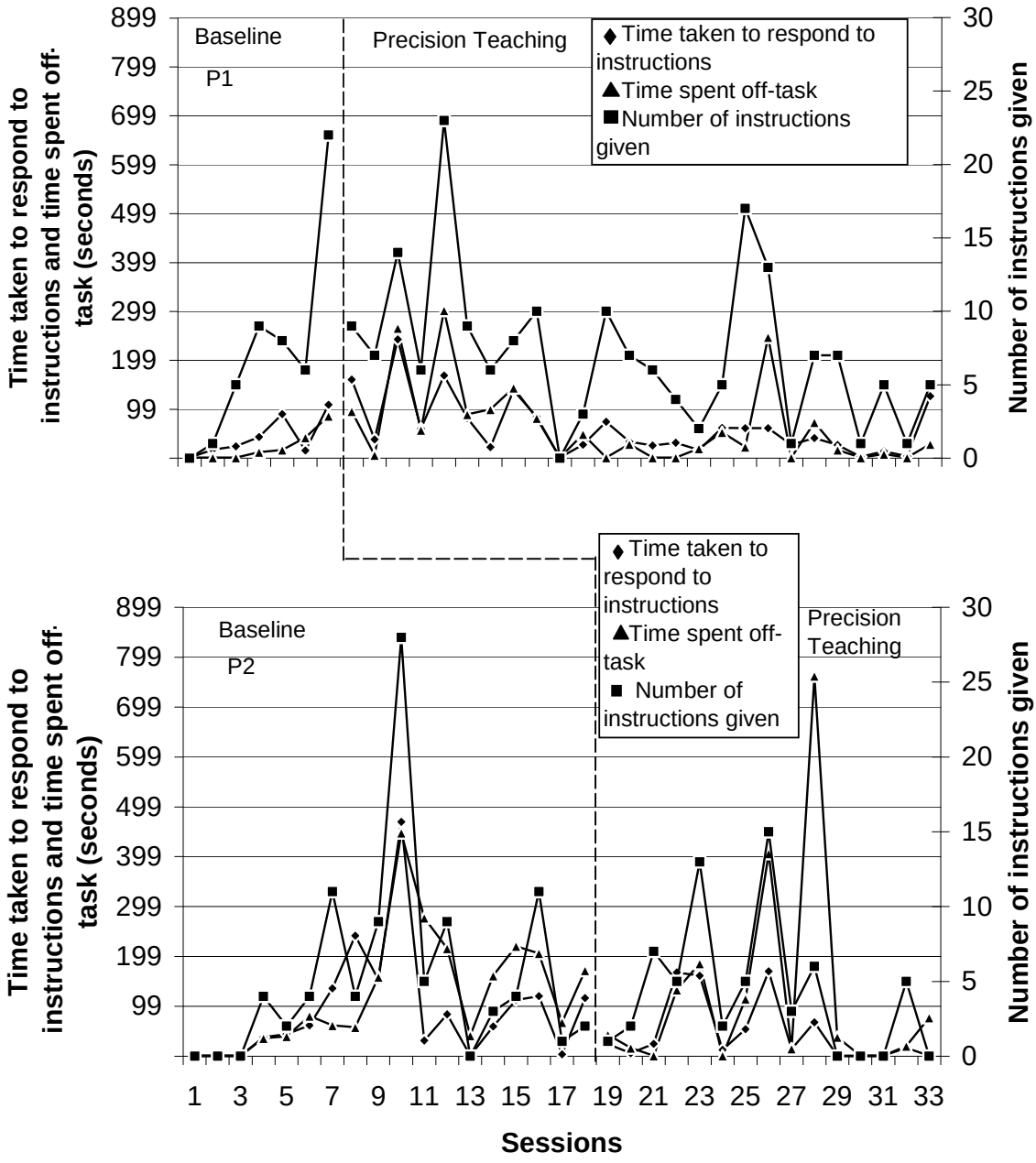

Figure 10. The time it took for P1 and P2 to respond to instructions, the number of instructions given, and the time they spent off-task, during each 15-minute observation session (the first three data points for P2 are actually missing data).

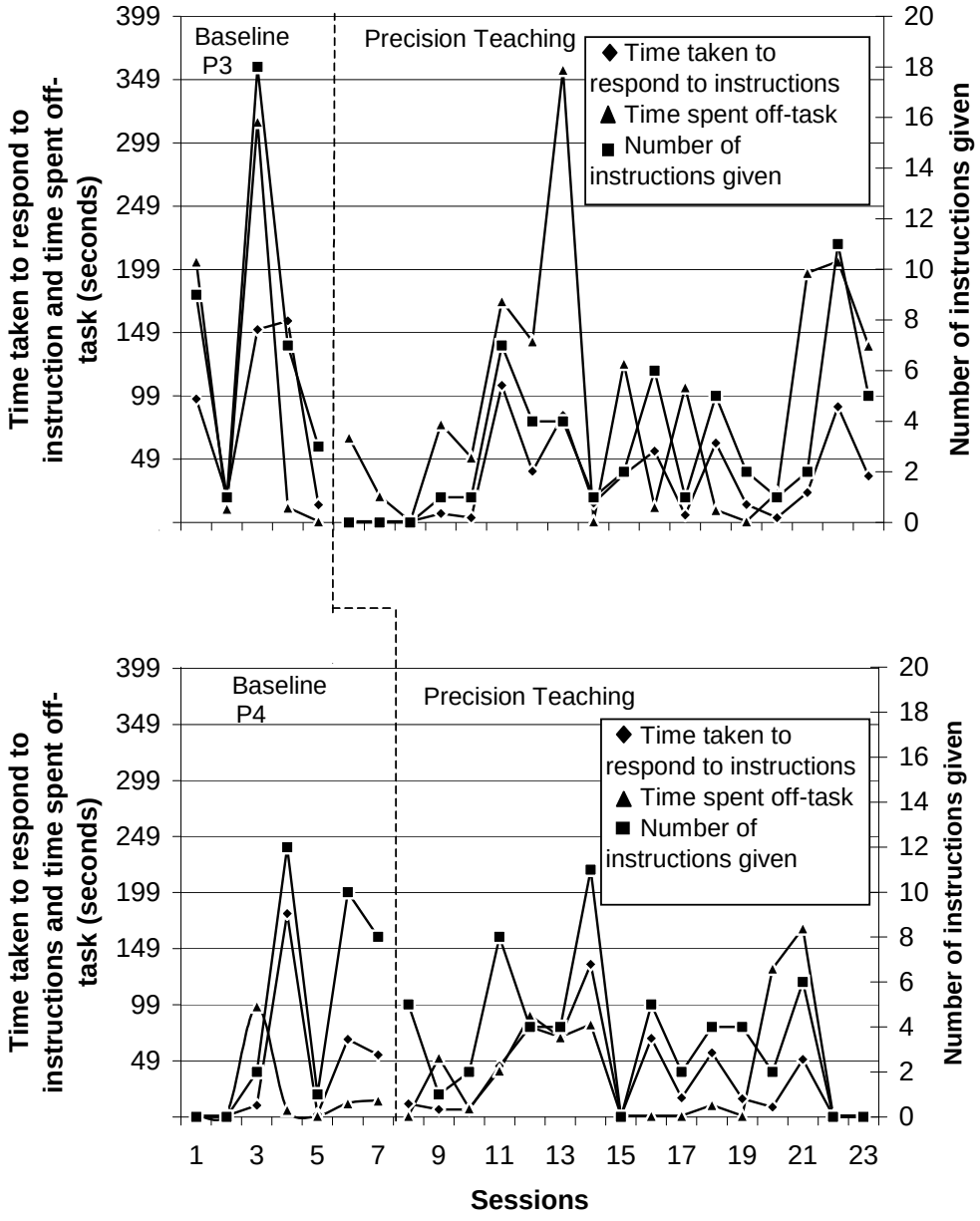

Figure 11. The time it took for P3 and P4 to respond to instructions, the number of instructions given, and the time they spent off-task, during each 15-minute observation session.

given before the participant responded, and the amount of time each participant spent engaging in behaviour other than what the teacher required of them.

Overall, the results obtained for P1 and P2 are rather similar, as for both participants there appeared to be an upward trend for all three behaviours over the first 10-12 sessions. Following this, there was either a downward trend evident or a decrease in time and frequency that then varied non-systematically over the remaining sessions. Over approximately the first 10 sessions, the time it took for both P1 and P2 to respond to instructions increased, although it took longer for P2 to respond to instructions than P1, with P1 reaching a maximum of approximately 250 seconds and P2 reaching almost 500 seconds. A downward trend was then evident with P1 whereas P2 showed a sudden decrease and then varied between approximately 0 and 200 seconds with no evidence of a trend. Roughly the same pattern was evident in the amount of time both participants spent off-task, with an upward trend over the first 10-12 sessions, followed by a downward trend over the remainder of the sessions, with the exception of one session for both participants. P2, however, seemed to spend more time off-task than P1. An upward trend was also evident over the first 10-12 sessions for the number of instructions given, however this then decreased, with a downward trend emerging for P1, with two exceptions, and a sudden drop occurring for P2 before varying non-systematically at this lower range.

The data in Figure 11 is rather different to Figure 10, as there are no trends evident; the data varies non-systematically for all three behaviours that were observed for both P3 and P4. These two participants were observed for fewer sessions than P1 and P2 though, as 15 observation sessions occurred for Group A before observation began for Group B. If Figure 10 is examined from session 16 onwards, there are some similarities between Group A and Group B. During this period, all the participants

took less than 200 seconds to respond to instructions and, except for P3, spent less than 200 seconds off-task. Also, usually less than 10 instructions were given to each participant over these sessions. It therefore appears that the data obtained for Group B is rather similar to the behaviour of Group A from session 16 onwards, however when compared with the previous sessions, there is generally a downward trend evident over these sessions for Group A.

The occurrences of aggressive behaviour are not seen in the above graphs, as there were only a few instances of aggressive behaviour observed for each participant. P2 behaved aggressively the most, with three sessions where two instances of aggressive behaviour were observed and one session where aggressive behaviour occurred once, prior to the arrival of the new teacher. After the arrival of the new teacher one aggressive behaviour was recorded. After this, there was only one other session where aggressive behaviour was observed, with nine acts of aggression recorded, resulting in the participant being restrained by the teaching assistant. Only one act of aggression was observed for P3 and this was during the third observation session. P1 and P4 both behaved aggressively twice, P1 twice in session seven and P4 once in both the 10th and 13th observation sessions. Overall, there were only one or two sessions where one or two acts of aggression were recorded for each participant, apart from P2 who exhibited aggression in six sessions.

Interobserver reliability.

A second observer was present during three observation sessions and as no critical moment was defined as to when a specific behaviour began and finished, it was expected that there would be a small amount of variation in the duration of the behaviour recorded. On average, over all three sessions, there was only 0.018% of

disagreement in the time the participants spent off-task, and 0.077% of disagreement in the time it took for the participants to follow instructions. There was no disagreement in the number of instructions given each session. There was also 100% agreement that the behaviours occurred, with no instances of aggressive behaviour recorded by either observer during any session. Given this, and the nature of the environment, it was decided that there was no need for any further interobserver sessions.

Summary of Results

All four participants showed a significant increase in the number of correct responses they emitted following the implementation of PT, as well as a decrease in the number of incorrect responses emitted. For all the participants, usually less than five incorrect responses were given each session after PT had begun, a dramatic decrease from the scores obtained during the baseline phase. All of the participants also reached the individual goals set for them. Out of 50 cards, P1 was able to say more than 30 of them correctly in one minute. P2 was able to say over 40 of the 45 cards he learnt in one minute (the school year ended before we had time to add the last five cards). P3 and P4 were able to correctly answer over 50 and 30 multiplication sums, respectively, in one minute. PT therefore seems to be an effective method for teaching target skills to children with ADHD but does it have any effect on other classroom activities and behaviour? In regards to reading for Group A and the multiplication worksheets for Group B, there seemed to be an increase in the number of correct and a decrease in the number of incorrect responses given following the implementation of PT for 3 out of the 4 participants, with the biggest effects probably evident in P1 and P4. In regards to recall for Group A and the division worksheets for

Group B, P1 and P4 were the only participants to show a slight upward trend in the number of correct responses given during the intervention phase. PT did not seem to have any effect on the measures of writing and word problem worksheets, as the only change evident for Group A was that as handwriting speed increased, accuracy decreased, and vice versa, and there was no change in the number of correct and incorrect answers given to the word problems for Group B. The observation results show that, following an initial upward trend in the time taken to respond to instructions, the number of instructions given, and the time spent off-task for Group A, a downward trend then became evident, however there was no trend evident for Group B. The change in Group A did not appear to coincide with the introduction of PT therefore it is unclear if PT had any effect on the targeted behaviours. The results therefore indicate that PT has an effect on the target skill and this is quite possibly applied to other activities that are directly related to the target skill, however there does not appear to be any evidence that new behaviours emerge as a result of PT in the target skill. This will be discussed further in the following section.

Discussion

The purpose of this study was to determine if PT is an effective method for improving the target skills of sight word recognition and multiplication for students diagnosed with ADHD. Furthermore, the issue of whether or not improvements in the target skill led to improved performances in other classroom activities, and in observed behaviour, was examined. It was found that PT is an effective method for teaching sight words and multiplication sums to children diagnosed with ADHD, however there was very little change evident in other classroom activities or behaviours, contrary to the suggestions of previous researchers.

All four participants reached the performance aims set for them for their target skill and this was a significant increase from the results obtained during the baseline phase. The performance level the participants reached, particularly P2 and P3, is also comparable with the performance level identified as demonstrating fluency in sight word recognition and multiplication in previous studies, this being 50 words or sums per minute (Downer, 2007; Fabrior & Moors, 2003; Hartnedy et al., 2005). ADHD students are often said to show deficits in reading and maths skills however the results of this study indicate that, with alternative teaching methods such as PT, ADHD students may perform at similar academic levels to other mainstream students. The results also show that once the participants had reached their performance aim, they were generally able to maintain their response rate as new cards were added. Response rates did, however, tend to decrease significantly after the school holidays. According to the literature, if fluency has been achieved then the response rate would be the same after the holidays as it was before i.e. performance would remain the same after a period with no practice (Binder, 1996; Haughton, 1980). The response rate quickly returned to the level prior to the holidays though, so to some extent

retention did occur, otherwise it would have taken as long as it initially took for the participants to learn the words/sums to regain the response rate prior to the holidays. It is also quite possible that it took the students a week or so to settle back into the school routine following the holidays and as such performance on all classroom activities may have been lower at first.

Improvements in the target skill for all the participants, including Initial P3, only began to occur once PT had begun, indicating that this change was due to the effects of PT. The use of the two dyad multiple baseline design further validates this finding, as this design clearly shows that changes in the target skill only became evident following the introduction of PT, not just from the continuation of normal schooling. The use of intermittent probing during the baseline phase for P2 and P4, after PT had begun with P1 and P3, was also a suitable method to use, as the baseline remained stable throughout both the continuous and intermittent data collection process. It is therefore not necessary to continuously subject the participants to repeated failure during the baseline phase; this is advantageous in getting the participants to partake in the study, as the high rate of avoidance behaviours evident in ADHD children are more likely to occur without regular positive feedback.

The classroom teacher did no specific teaching on sight words and multiplication whilst this study was being conducted and she commented that the reading and maths levels of the participants appeared to have increased over this time and believed that PT played a part in this. This was not empirically tested though, however future research could look at the reading and maths levels of the participants prior to and following the intervention. Other students in the classroom could also be used as a control for measuring any changes in reading and maths levels, because if there were no improvements evident in the control group, but there was in the PT

group, then the changes in reading and maths could be attributed to PT as opposed to other general classroom instruction.

ADHD children tend to perform better when they are positively reinforced for their work (Zentall, 2005) and although PT provides the opportunity for such reinforcement in the form of regular positive feedback regarding their progress, Zentall (2005) stated that ADHD children tend to work better for tangible rewards therefore in this study the participants also received stickers if they reached the daily goals set for them. Similarly, Hartnedy et al. (2005) used PT in a study involving children diagnosed with ADHD and he gave his participants stickers when they reached performance aims. Hartnedy et al. (2005) actually focused on multiplication with one of these participants who met the set criteria of answering 50 sums correctly within one-minute; this is comparable with P3 in this study who was also able to perform the same skill at the same level. Both studies therefore involve the use of PT with tangible reinforcement and as such it is unclear how much of a role, if any, the stickers played in the outcome. This could be determined if a further study was designed that did not include the use of tangible reinforcement, or removed the tangible reinforcement and then added it back in, for example an ABAB design, to see if there is any difference in behaviour in the different conditions.

ADHD children often exhibit disruptive classroom behaviour and have difficulty attending to the work required of them, however in this study, on all but a few occasions, the participants complied with the PT task over the duration of three terms. This implies that the instructional method was acceptable to these children over a long period. This may be due to a variety of reasons. For example, each session was of a short duration and new cards were only added once the previous cards were known therefore the difficulty of the task was continuously matched with the ability

of the student; these factors have been shown to be important when teaching students with ADHD (Zentall, 2005). Leung et al (2000) found that when students with ADHD practiced tasks by responding in a fast paced and repetitive manner that the level of attention they gave to the task was the same as non-ADHD students. The very nature of PT is based on quick and repetitive responding so this may contribute to the success of PT with this subpopulation. Furthermore, the participants were provided with consistent and specific instructions, as they knew not only how many cards they had to attempt each day and the criteria for adding new cards, but also that they were always timed for one-minute and the number of cards they got right or wrong during this time was recorded. Providing such instruction is considered to be an important aspect of how children with ADHD tend to learn best (Ostoits, 1999; Zentall, 2005). Also, in this study, each participant was worked with on an individual basis and this is thought to be beneficial for ADHD students (Ostoits, 1999). Future research could, however, look at instructing the participants on PT and then allowing them to administer it themselves, as providing this subpopulation with self-management strategies has been shown to help with their learning (Shapiro et al., 1998). Allowing the students to monitor their own performance, particularly through the use of charts, has previously resulted in more tasks being attempted, attended to, persisted with, and performed correctly (DeHaas-Warner, 1991, as cited in Zentall, 2005) and this may have contributed to not only the high rate of compliance by the participants in this study but also the high standard of performance. The success of the compliance levels over a long period, and of improving the participants' performance in their target skill through the use of PT, may be attributed to by these aforementioned close links between the PT method and the characteristics of how children with ADHD tend to learn best.

Although there were improvements evident in the target skills being taught to each participant, it appears that these skills were only minimally applied to other classroom activities and no new behaviours emerged as a result of the PT process. Group A were required to read from a reader that the teacher deemed to be at an appropriate level for their reading ability. The results indicated that both participants were able to read slightly more words correctly following the implementation of PT than during the baseline phase, however this difference is more evident in the later sessions conducted, possibly indicating that as more and more words were learned through PT, more words were recognised by sight when reading from a reader. This was to be expected as being able to recognise words by sight is considered a crucial aspect of developing reading skills (e.g. Ehri, 1991; Kuhn & Stahl, 2003), and Downer (2007) suggested that overall reading performance was enhanced following PT in sight word recognition. The results are, however, quite variable and this may be due to some readers having more recognisable words in them than other readers and, in the occasional session, the participant had read the reader used for the study sometime previously in class. This problem could be addressed in a future study by comparing the words in each reader with the words on the SAFMEDS cards. Also, often words are repeated in a reader and if it is a word that is known then it increases the results for that session but if it is a word that is not known then it decreases the results for that session. One way of addressing this is by finding readers that do not repeat words many times, yet this may prove difficult as this is often the case with readers at the level being used. Further analysis into the words that were read correctly and incorrectly each session would provide a greater understanding of the degree of the application of the skill of sight word recognition to reading readers.

Similarly, the participants in Group B were required to try and answer multiplication sums on a worksheet and there was a change evident in P4's results, but not P3's, following the implementation of PT. P4 got more answers correct and less incorrect during the intervention phase than during the baseline phase, indicating that she was applying some of the knowledge learnt during PT to this activity. It might appear that the lack of change evident for P3 weakens the argument that PT may have an effect on this classroom activity, however P3 seemed to be the most defiant participant and would often simply speed through the sheets, putting crosses for the ones he did not know, yet it was quite clear he was not even attempting to think about the answer. If he tried to answer the sums, the results may have been a bit different. It would appear though, that this task did not have as much control over P4's behaviour as the PT task did i.e. the rate of non-compliance increased when getting him to perform more traditional classroom activities than when he was doing PT. This non-compliance means that these sheets were not a legitimate measure of his knowledge yet at the same time it shows that the skills learnt through PT may not be applied to other classroom activities due to a lack of compliance as opposed to a lack of knowledge. A further problem with these worksheets was that the sums were generated randomly from a maths website and the sheets for some sessions could contain more sums from the one, ten and sometimes five times tables than the sheets in other sessions and this biased the results as usually more correct answers were given if there were more of these sums on the worksheets. One way of controlling for this in future studies could be to check the difficulty of the sheets and ensure that there is an even representation of the times tables across sessions; these sheets could be pre-tested by a student.

The reading and multiplication worksheets were the most closely related activities to the skill being taught through PT and overall it appears that there was some application of the target skill to these activities. According to the literature, there appears to be an expectation that if a component skill is performed at a high rate of accuracy and frequency then composite skills are learnt more quickly (Binder, 1996) and similarly, component skills are more readily applied to other tasks. For example, in The Great Falls Project, improvements on subtests of the Iowa Test of Basic Skills occurred after PT had been conducted for a number of component skills, indicating that the skills learnt through PT were applied to the test (Beck & Clement, 1991). Similarly, Peladeau et al. (2003) found that exam scores improved after the component skills required for successful problem solving had been practiced to a level of mastery, indicating that this skill was applied in exams. It therefore stands to reason that there would be some application of the target skill in this study to another classroom activity, however this did not extend beyond reading and the multiplication worksheets, as some studies suggest may have occurred, an area that will now be discussed.

The participants in Group A were read a short picture book and then asked to recall as many facts about it as they could within one-minute, with the aim of determining if there was any change in this behaviour following the implementation of PT. P1 and P2 were also required to copy a passage of writing for one minute. If there was a big improvement in the participants' recall ability or handwriting it could have been suggested that these new behaviours of greater recall and writing skills emerged as a result of the PT process. Similarly, the participants in Group B were given worksheets that contained division equations and word problems involving multiplication to determine if PT on the target skill of multiplication had any effect on

the answers given in the worksheets. If the number of correct answers given on the worksheets increased once PT had begun then it could have been said that the new behaviours of being able to do division and solve word problems had emerged as a result of PT focusing on multiplication. If improvements were evident in any of the four aforementioned measures following the intervention then these new behaviours would have emerged without any direct training; this is characteristic of adduction and there are some suggestions noted in previous research that new behaviours can be learned without being directly taught.

For example, Bucklin et al. (2000) taught participants two component skills, these being learning arbitrary associations between Hebrew characters and nonsense syllables, and between Arabic numerals and nonsense syllables. The participants were then required to apply this knowledge in a novel situation whereby they had to write the answers to Hebrew arithmetic problems in Arabic numerals and it was found that they were able to perform this new behaviour without being directly taught how to do so (Bucklin et al., 2000). Similarly, Johnson and Layng (1992) showed that by training participants on two components skills, these being whole number problem solving and calculating with fractions, that the composite skill of being able to perform word problems with fractions was achieved i.e. no direct training was provided for this skill but it emerged as a result of training the two component skills. In this study, the participants in Group B were told that division is the inverse of multiplication and they were provided with brief instruction on this concept. Considering P3 and P4 were being taught multiplication using PT, it was thought that if they were told division was the opposite of multiplication that they might be able to use their knowledge of the times tables to answer division questions, without being directly taught a set of division equations. The results, however, indicate that

adduction did not occur in this instance, as there was no change in the number of correct and incorrect answers P3 gave on the division worksheets following the implementation of PT, and there was only a slight increase in the number of answers P4 got correct and no decrease in the number of P4's incorrect responses. Unlike Bucklin et al. (2000) and Johnson and Layng (1992), whereby two component skills were combined to produce a new behaviour, the instruction on division given to P3 and P4 did not combine with the multiplication sums they had learnt through PT to produce the new behaviour of division.

Furthermore, Johnson and Layng (1992) showed that separately training whole number problem solving and calculating with fractions achieved the composite skill of solving word problems with fractions. Similarly, it was thought that training on multiplication might adduce into the new behaviour of being able to solve word problems involving multiplication, however this did not occur, as there was no change in the number of correct or incorrect answers given on these worksheets following the implementation of PT. If the changes evident in the target skill of multiplication were applied to the word problem worksheets then the rate of correct responses would have increased, as the participants would have known the answers to the problems, as they knew the answers to the sums on the cards. Being able to perform multiplication with words is a completely new behaviour though, as the numbers to be multiplied have to be extracted from other irrelevant information and children with ADHD can often find it difficult to extract the relevant information needed for a task (Zentall, 2005).

Perhaps if training was incorporated on the component skill of extracting the relevant information from the word problems then, along with PT on multiplication, these two component skills might result in the new composite behaviour of solving word problems with multiplication. A possible problem with this measure was that the

word problems randomly used factors from all the cards the participant was going to be taught so there were often word problems on the worksheet for each session that the participant had not yet learnt the sum for through PT. This means that the measure was not necessarily accurate in recording if what had been learnt using PT was applied to the word problem worksheets. A possible way of correcting this would be to ensure that the word problems did not contain any factors from time tables not yet learnt by the participant.

There was also no evidence of adduction in regards to recall for Group A, as a very slight increase in the number of facts recalled for P1 was the only change in this behaviour following PT on sight word recognition. Two issues that would need to be taken into consideration if this study were replicated is that some books were longer than others thus required the participants to remain attentive for a longer period, and the content of some books appeared to be more interesting to the participants than others. This could be accounted for by ensuring that the books used were all of relatively equal length and interest. Likewise, there is no evidence of adduction in regards to handwriting, as there were no improvements in handwriting following the implementation of PT. The only change evident was an increase in speed corresponding with a decrease in accuracy and vice versa. Perhaps this was to be expected though, as the new behaviours that are talked about as adduction in the literature generally have some link to the component skill(s) being taught, such as writing the answers to Hebrew arithmetic problems in Arabic numerals, a composite skill based on learning these two components separately (Bucklin et al., 2000). Perhaps a more pertinent measure would have been to test the spelling of the words being used for PT to determine if the new behaviour of spelling emerged as a result of reading the words during each session.

Although the literature suggests that sometimes new behaviours emerge without any direct training, in this study it appears that there is no evidence of adduction. There does appear to be some evidence of the application of the target skill to other behaviours, although it is minimal. Perhaps the possibility of adduction and the strength of the application would be greater if higher response rates during PT were obtained, as Binder (1996) suggests that higher frequencies of responding on component skills leads to the easier acquisition of composite skills. The response rates of the participants in this study, however, were roughly the same standard as in other studies (e.g. Downer, 2007; Hartnedy et al., 2005) therefore the lack of evidence of adduction, and the minimal application, is probably due less to the response rates and more to the idea that although the target skill improves through PT, at the very most it is only applied to closely related activities and no new behaviours emerge without direct training. It would therefore be interesting to conduct future research that examines the use of PT with each of the other measures to see if recall, writing, division and solving word problems are improved with direct training, or if using PT to teach another component skill of the various measures, in conjunction with PT in sight words and multiplication, results in improving these behaviours i.e. a composite behaviour emerges without any direct training due to teaching two component skills. Most of the previous research that shows evidence of adduction has generally been done in such a way i.e. two specific skills are directly taught and then it is tested whether a new specific skill has emerged. It could therefore have been expected that there would be no changes in the measures used in this study unless some other component was directly taught that could have combined with sight words or multiplication to produce a new skill. It appears that adduction occurs best under more contrived conditions as opposed to new behaviours randomly emerging.

Some studies have also suggested that improving a target skill with the use of PT can lead to improvements in general classroom behaviour. For example, Downer (2007) stated that after PT had been used to increase sight word recognition in a sample of school children that changes were evident in the participants' confidence, self-esteem and temper control. Not only are these hypothetical constructs, but they were also not directly measured. This study therefore attempted to define operational definitions of some specific classroom behaviours, these being the time taken to respond to instructions, the number of instructions given before the desired response occurred, the time spent engaging in off-task behaviour, and any instances of aggressive behaviour. These measures were observed and recorded in order to determine if PT had any effect on classroom behaviour, and all of them except aggression were graphed, as there were only a few instances of aggression throughout the entire study. It was found that an upward trend was evident over the first 10-12 observation sessions for P1 and P2 but that a downward trend then emerged over the remaining sessions for all the behaviours that were graphed. This change however did not coincide with the introduction of PT but instead appears to be related to a new teacher arriving in the classroom to replace the previous teacher. Observation only began for P3 and P4 once this new teacher had arrived and there appears to be no trends evident for this group, suggesting that PT did not have any effect on the identified behaviours. The results for both groups are rather comparable following the introduction of the new teacher. This study therefore conflicts with the suggestions made by Downer (2007) that PT can have an effect on more general classroom behaviours, as the only change in this study appears to be related to the new teacher arriving, not PT beginning. Perhaps though, it is more a measurement issue, as if the new teacher had been less skilled in managing the classroom behaviour then some

outcomes of PT may have become evident but because the children's behaviour was very good anyway, due to the control the new teacher had over their behaviour, it is hard to tell if PT had any effect, a situation sometimes referred to as a setting effect.

There are, however, some further issues with the data, such as that during some sessions more instructions were given than in other sessions due to the nature of the class that day which leads to higher response times being recorded. Also, the analysis shows that, for example, once the new teacher arrived, less than 10 instructions were given to each participant in each session, however it is unknown whether this is 10 different instructions or the same instruction repeated 10 times and so forth. The analysis could be broken down into further components to determine this. A further issue is that if the task was one that the students seemed to enjoy then they were more likely to remain on task; identifying the task the participant should be engaging in when they are off-task could help explain why there were more occurrences of off-task behaviour in some sessions than others. An attempt was made to account for these issues by trying to conduct the observation sessions at the same time every day. Furthermore, if the same classroom activity was observed each day then the amount of off-task behaviour recorded would not be affected by the level of enjoyment of different activities, however this is not very practical, as the schedule often changes. Although this observation data could be further broken down for a more in depth analysis, overall there does not appear to be any change in the identified behaviours due to PT occurring and this further supports the other findings in this study which show that adduction has not occurred, i.e. completely new behaviours have not emerged simply as a result of PT in a target skill.

Summary and Conclusions

This study quite clearly demonstrates the effectiveness of PT in improving the target skills of sight word recognition and multiplication in the subpopulation of ADHD school children. These target skills appeared to be minimally applied to other classroom activities, and new behaviours did not seem to emerge as a result of the PT process, but PT is definitely an effective method for improving base skills that is also easily implemented in the classroom setting. The costs involved and the disruption to the daily classroom schedule are minimal. The students could quite easily be instructed on how to do PT themselves, with the teacher merely providing a guiding role. In this classroom setting the teacher often gave the children individual tasks to complete for the day and they would work on these tasks independently; the use of PT in such a setting would therefore fit in perfectly. PT could be used for a variety of component skills and, following mastery in one component, the next level could be taught using this method. The effectiveness of this method, combined with the easy application of it in the classroom setting, renders PT a beneficial alternative method for teaching skills to children with ADHD.

The diagnosis of ADHD in school children has become increasingly widespread and these children are often reported to exhibit academic difficulties, particularly in the areas of reading and mathematics. It is quite possible, however, that these children do not necessarily have deficits in these areas so much as problems in performance i.e. it is not the cognitive abilities of the child that is inadequate but rather their ability to remain on task and to not become frustrated with tasks, often avoiding them as a result (Hinshaw, 1992). Although ADHD children are often prescribed medication to help them with their behavioural problems, there is no evidence to suggest that this helps them academically (Berthiaume, 2006). This study

has shown that PT can improve the target skills of sight word recognition and multiplication in this subpopulation and it is a technique that can be administered easily within the school setting. Furthermore, although ADHD children are often thought to be non-compliant, disruptive and difficult to get to remain on task (Lahey et al., 1998; Sagvolden et al., 2005), the participants in this study are attending the Kauri Centre because their behavioural problems are more severe than the typical ADHD child, yet all of these participants were generally compliant and engaged in the PT task for the required duration. Considering it was possible to get these children to learn through PT, then it is almost guaranteed to be an effective method to use with other children who are diagnosed with ADHD but do not exhibit such extreme antisocial behaviour. There may be a number of reasons for the effectiveness of PT, such as the short duration or the monitoring of results, or a combination of all the characteristics of PT; whatever the reason, dramatic improvements were made in the target skills and PT could be used to further build on these skills with the aim of improving the composite skills of reading and mathematics. PT is therefore an alternative teaching method that needs to be seriously considered for use when teaching students with ADHD, and in turn the reading and maths deficits so prevalent in ADHD students at the moment may slowly disappear.

The characteristics of PT meet many of the learning requirements of those diagnosed with ADHD, and these characteristics may also match the learning requirements of students in remedial reading or maths tuition. This is an area that needs to be examined, as it may be that children in remedial classes are not being taught the way they need to learn best and as such PT may be an alternative method suited to this subpopulation too. Not only might it be an effective teaching method, it could also have the added benefits of being implemented in the classroom and being

cost effective. PT has already been shown to be effective in teaching children with disabilities and now this study has shown the effectiveness of using it to teach children with ADHD, and future studies could explore the effectiveness of PT in place of current remedial tuition. Overall, different techniques are needed when children are struggling to learn and as such PT is a very effective alternative teaching method that is also cost effective and easily implemented; PT leads to positive academic results in subpopulations that may have otherwise been seen to have learning difficulties.

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Appendix A

Research Consent Form

University of Waikato
Psychology Department

CONSENT FORM

PARTICIPANT'S COPY

Research Project: Do ADHD children show any changes in performance of classroom activities and other behaviour following Precision Teaching in a targeted skill?

Name of Researcher: Veronica George

Name of Supervisor (if applicable): Mary Foster

I have received an information sheet about this research project or the researcher has explained the study to me. I have had the chance to ask any questions and discuss my participation with other people. Any questions have been answered to my satisfaction.

I agree to participate in this research project and I understand that I may withdraw at any time. If I have any concerns about this project, I may contact the convenor of the Research and Ethics Committee (Dr Robert Isler, phone: 838 4466 ext. 8401, e-mail r.isler@waikato.ac.nz)

Participant's
Name:_____Signature:_____Date:_____

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Appendix B

Complete Dolch Word List Divided by Level

Pre-primer	Primer		Grade One	Grade Two		Grade Three
a	all	under	after	always	why	about
and	am	want	again	around	wish	better
away	are	was	an	because	work	bring
big	at	well	any	been	would	carry
blue	ate	went	ask	before	write	clean
can	be	what	as	best	your	cut
come	black	white	by	both		done
down	brown	who	could	buy		draw
find	but	will	every	call		drink
for	came	with	fly	cold		eight
funny	did	yes	from	does		fall
go	do		give	don't		far
help	eat		going	fast		full
here	four		had	first		got
I	get		has	five		grow
in	good		her	found		hold
is	have		him	gave		hot
it	he		his	goes		hurt
jump	into		how	green		if
little	like		just	its		keep
look	must		know	made		kind
make	new		let	many		laugh
me	no		live	off		light
my	now		may	or		long
not	on		of	pull		much
one	our		old	read		myself
play	out		once	right		never
red	please		open	sing		only
run	pretty		over	sit		own
said	ran		put	sleep		pick
see	ride		round	tell		seven
the	saw		some	their		shall*
three	say		stop	these		show
to	she		take	those		six
two	so		thank	upon		small
up	soon		them	us		start
we	that		then	use		ten
where	there		think	very		today
yellow	they		walk	wash		together
you	this		were	which		try
	too		when			warm

Appendix C

List of Readers (in order they were read)

P1		***P2***	
Title of Book	**Author**	**Title of Book**	**Author**
Packing my Bag	Annette Smith	Jolly Roger and the Pirate	Beverley Randell
A House	PM Reader	Farms	Sandra Iversen
Look at Me	PM Reader	Big and Little	Joy Cowley
Me	PM Reader	The School Band	Dot Meharry
My Best Bear	Dot Meharry	The Week it Rained	Susan Frame
Making a Rabbit	PM+	Where are the Sunhats?	Beverley Randell
The Picnic	Margaret Schroder	The Hissing Bush	Trish Puharich
Going Fishing	Dot Meharry	Gumboots	Tracey Garner
Training Ruby	Jane Buxton	Ben's Dad	Beverley Randell
The Race	Feana Tu'akoi	Baby Bear goes Fishing	Beverley Randell
Time for Dinner	PM Reader	Sally and the Sparrows	Jenny Giles
Pets	PM Reader	The Pirate's Treasure	Joy Cowley
The Shopping Mall	PM Reader	Sally's Beans	Beverley Randell
Making a Dinosaur	PM Reader	Brave Father Mouse	Beverley Randell
Playing	PM Reader	Fly Baby Bird Fly	Susan Frame
We Go Out	PM Reader		
The Skier	PM Reader		
A Friend for Me	Jane Buxton		
The Way I go to School	PM Reader		
Making a Bird	PM Reader		
The Present	Kay Hancock		
The Picnic	Karen Anderson		
The Sandcastle	Jane Buxton		
Going in the Car	Belinda Thompson		
At the Zoo	PM Reader		
The Clown	Karen Anderson		
In our Classroom	PM+		
What Do I See	Dot Meharry		
Too Big	Materoa Tangaere		
Playing	PM+		
Dressing Up	PM Reader		
We get Squashed	Philippa Werry		
Make It	Beth Becker		
Who Took the Cake	Eduardo Medina		
Thanksgiving	Eduardo Medina		
Trouble	Pauline Cartwright		

Appendix D

List of Picture Books (in order they were read)

P1		***P2***	
Title of Book	**Authors**	**Title of Book**	**Authors**
Amazing Aeroplanes	Tony Milton and Ant Parker	Skateboard	Marcia Vaughn
Dino-Dinners	Mick Manning and Brita Granstrom	Dad's Takeaways	Melanie Drewery
The Little Yellow Digger Goes to School	Betty and Alan Gilderdale	The Forgotten Taniwha	Robyn Kahukiwa
Our Train	Beatrice Phillpotts	Big Rigs	Robert Gould
Beaky's Birthday Surprise	Scott Wilson	The Little Yellow Digger Saves the Whale	Betty and Alan Gilderdale
Harry and the Dinosaurs go to School	Ian Whybrow and Adrian Reynolds	Child of Aoteroa	Melanie Drewery
Keeping Safe, Careful and Cool		Soccer	John Lockyer
Skateboard Bill	Marcia Vaughn	The Car Wash	Harley Chan
Triceratops	Pam Holden	Rhinos Who Surf	Julie Mammano
Crazy Creature Contrasts	Hannah Reidy	The School Band	Dot Meharry
T-Rex	Pam Holden	Jobs People Do	Pam Holden
The Car Wash	Harley Chan	Machines Make Fun Rides	Belle Perez
Friends you can Count on	Debbie Tipuna	Big Machines	Diane Freeman
The Hissing Bush	Trish Puharich	Perfect Pets	Julie Ellis
Teeth	Julie Ellis	Breakfast at the Zoo	Pam Holden
Fast and Noisy	Pam Holden	Our Tree House	Pam Holden
Jobs People Do	Pam Holden	After Dark	Pam Holden
Count-a-saurus	Nancy Blumenthal	Fast and Noisy	Pam Holden
Ants	Arna Mountain and Jan van Der Voo	Rainbow Balloons	Pam Holden
George, the Dragon and the Princess	Chris Wormell	Simple Technology	Pam Holden
One Day at the Zoo	Donna Bryant	How Does My Bike Work?	Jan Macpherson
One Day at the Park	Donna Bryant	Skyscrapers	John Lockyer
The Rainbow Fish	Marcus Pfister	Desert Rain	Pat Malone
One Day at the Seaside	Donna Bryant	Our Town	Faridah Yusof
Breakfast at the Zoo	Pam Holden	The Milky Way	Barry Holden

Watch the Sky	Jacob Fink	Mrs Snip Snap	Pam Holden
Sea Life	Pam Holden	Baby Animals	Pam Holden
Rainbow Balloons	Pam Holden	We Forget	Pam Holden
Our Town	Faridah Yusof	Making Milk	Pam Holden
How Does My Bike Work	Jan Macpherson	In My Lunchbox	Pam Holden
Simple Technology	Pam Holden		
Who Has Stripes?	Pam Holden		
In My Lunchbox	Pam Holden		
Mrs Snip Snap	Pam Holden		
Making Milk	Pam Holden		
Baby Animals	Pam Holden		
What Lives in a Swamp?	Jacob Fink		
We Forget	Pam Holden		

Appendix E

Example of Multiplication Worksheet for P3

$7 \times 7 =$ ___ $1 \times 7 =$ ___

$7 \times 4 =$ ___ $10 \times 8 =$ ___

$7 \times 1 =$ ___ $5 \times 5 =$ ___

$5 \times 3 =$ ___ $1 \times 5 =$ ___

$5 \times 9 =$ ___ $9 \times 1 =$ ___

TheMathWorksheetSite.com

Appendix F

Example of Multiplication Worksheet for P4

3 × 7 = ___	8 × 5 = ___
4 × 8 = ___	2 × 4 = ___
5 × 6 = ___	10 × 5 =___
7 × 2 = ___	6 × 3 = ___
2 × 2 = ___	5 × 1 = ___

TheMathWorksheetSite.com

Appendix G

Example of Division Worksheet for P3

60 ÷ 6 = ___ 40 ÷ 5 =___

10 ÷ 10 =___ 8 ÷ 8 = ___

60 ÷ 10 = ___30 ÷ 5 =___

49 ÷ 7 = ___16 ÷ 8 = ___

7 ÷ 1 = ___ 4 ÷ 2 = ___

TheMathWorksheetSite.com

Appendix H

Example of Division Worksheet for P4

28 ÷ 4 =___ 10 ÷ 1 = ___

40 ÷ 4 =___ 12 ÷ 4 = ___

20 ÷ 4 =___30 ÷ 3 = ___

6 ÷ 2 = ___ 27 ÷ 3 = ___

8 ÷ 4 = ___ 40 ÷ 5 = ___

TheMathWorksheetSite.com

Appendix I

Example of Word Problem Worksheet for P3

If Mary and Jane both have two apples, how many apples are there altogether?

If there are four rugby teams with seven players in each team, how many players are there in total?

If three people score six goals each, how many goals were scored?

If there are three cars, with five people in each car, how many people are there altogether?

If nine children are going to the beach and they all have two spades, how many spades are there?

If three people buy one ice cream each, how many ice creams were bought?

If a rugby player scores five tries, and each try is worth five points, how many points did he score?

If four people each have eight chocolates, how many chocolates are there altogether?

If six hens lay seven eggs each, how many eggs are laid in total?

If a runner runs nine laps, and each lap takes eight minutes, how long is he running for?

Appendix J

Example of Word Problem Worksheet for P4

There are four chairs around a table. Each chair has four legs. How many legs are there altogether?

Three children go to a birthday party. They each take one present for the birthday girl. How many presents did the birthday girl get?

In my pencil case I have three pens. In my friend's pencil case there are three pens. How many pens are there altogether?

There are five books on each of two shelves on my bookcase. How many books are there altogether?

I went to the store twice last week and each time I bought four lollies. How many lollies did I buy?

I have three CDs with five songs on each CD. How many songs are there altogether?

If I walked around the block twice and each time it took me four minutes, how many minutes was I walking for?

Appendix K

Handwriting Measure

A review of the literature showed that although there are differences between the various methods that have been developed to score handwriting, such as the Children's Handwriting Evaluation Scale, Freeman's Scale and the Grey Score Card, there appears to be five common elements represented throughout them all, these being legibility, form, alignment, size and space (Feder & Majnemer, 2003; Phelps, Stempel & Speck, 1985; Ziviani & Elkins, 1984). The Minnesota Handwriting Test consists of these five categories and this is the method that was used to score the handwriting in this study. Each letter is given a point if it meets the requirements of each category so that a total of five points is possible per letter (Feder & Majnemer, 2003). If the requirements for legibility were not met, then the letter is no longer scored. Legibility requires that the letter can be decoded out of context and that it is written the right way around and contains all the necessary strokes (Feder & Majnemer, 2003). In this study if the letter was not copied it also rendered a score of zero. A letter scores a point on 'space' if there is a gap no bigger than six millimetres between it and the next letter (Feder & Majnemer, 2003). For this study, if the letter was the start of a new word, there needed to be a gap of between 6mm and 1.3cm from the end of the previous word, or it needed to be within 2mm of the letter written to copy, to score one point. One point was scored for 'alignment' if the letter was written within 2mm above or below the line (Feder & Majnemer, 2003). Likewise, for 'size' a point was scored if it was within 2mm of the size of the letter written to copy (Feder & Majnemer, 2003). One point was given for 'form' if the letter was closed and if any overlaps were less than 2mm, as well as if there were no extra bits added to the letter (Feder & Majnemer, 2003). For each passage of writing done in the one-minute time period, the number of points scored for each letter was added up and a

percentage was calculated based on the total possible amount of points that could have been obtained for that passage; this was used to determine the accuracy of the participants handwriting. The Minnestoa Handwriting Test requires participants to copy a passage for 2.5 minutes to determine rate (Feder & Majnemer, 2003), however in this study the number of letters written in each one-minute session was recorded to determine rate.