Using precision teaching to increase the fluency of word reading with problem readers

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This study describes the effectiveness of a brief intervention aimed at increasing the rate (frequency) of reading common English words for five pupils who were experiencing problems with reading. The intervention employed frequency-building procedures aimed at increasing the rate at which the children could read words accurately, and precision teaching (PT) to monitor the effectiveness of the intervention. The children in the treatment as usual (TAU) condition received the standard reading support during the same period. All of the pupils' were tested at pre- and post-intervention on the frequency at which they could read words accurately, and all were given a standardised reading test. Following intervention the outcome measures for fluency were taken: maintenance, endurance, application, and stability. All five of the PT children increased their rate of accurate word reading, and two made significant gains on the standardised tests of reading; however, the TAU children did not improve on any of the measures. The study provides additional evidence supporting the effectiveness of PT and frequency-building procedures, and that successful intervention need not require expensive or time-consuming resources.

Key words: Precision Teaching, reading, education, fluency, frequency-building procedures, literacy, Standard Celeration Chart

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The ability to read is perhaps the most important academic skill. Reading is the primary medium for the transfer of knowledge in all curriculum areas (Cawley, Miller, & Carr, 1990), and as such is a prerequisite skill required for much of what children learn in schools (Barber, 1997). A child without at least an average grade-level reading ability will find it difficult to progress adequately in core curricula and is already experiencing, or is facing, academic failure. With this failure the child will almost certainly lack a number of the key repertoires necessary to enter many employment domains in a modern information driven society (see e.g., Doyle, 1983). According to Salvia and Hughes (1990) the understanding of written text determines a student's success or failure in all post primary academic subjects. Indeed, Stuart (2006) asserts that many children in the UK are not reading satisfactorily by the end of primary education and are thus unprepared to effectively engage with the secondary school curriculum.

In addition to the cost to individuals, a survey conducted for the Basic Skills Agency by Gallup (ALBSU, 1993) estimated that inadequate basic skills cost UK industry in excess of £4.8 billion a year. Furthermore, the National Assembly for Wales estimated the annual cost to the Welsh economy of poor basic skills was £588 million (The Basic Skills Agency & The National Assembly for Wales, 2001). A survey conducted by the Basic Skills Agency (1988, as cited in The Basic Skills Agency, 2001) found that 780,000 people in Wales had literacy and numeracy problems. Furthermore, by the age of 11, 22% of Welsh children had not reached the required level for English, and by the age of 14 this had increased to 38%.

The Basic Skills Agency has made a commit-

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ment to improve the standards of basic skills across England and Wales (The Basic Skills Agency, 2001). Although reading is a complex task, in a simplified sense it can be described as the ability to decode or identify words and comprehend what has been read (King-Sears, 1994). Some of the key skills in reading include, *decoding* (breaking words down into sound elements or phonemes and then blending these sounds into whole words) and *word recognition* (fluent identification of whole words); without such skills, understanding of text will be difficult. One approach to learning that has had over four decades of success in improving basic skills is *precision teaching* (PT) (Beck & Clement, 1991; Johnson & Layng, 1994; Johnson & Street, 2004; Kubina & Starlin, 2003).

PT builds frequency in basic skills and helps teachers ensure that *every child in a class* is learning successfully. PT is a general approach that can determine whether an instructional method is achieving its aims. It is not, as the name might imply, a method of teaching; however, it does encourage certain practices that are not commonly used within UK classrooms, such as short practice sprints, daily measurement of performance, and data driven pedagogical decisions. It could be more accurately described as *precision measurement* because it is primarily a sensitive, student-centred learning measurement tool (Boyce, 2003). The value of PT lies in identifying a specific skill area (e.g., reading numbers) in which the child is either failing to progress or is performing below a level considered to be competent; this is then followed by a daily session of teaching, frequency building, monitoring and evaluating progress, and adapting to this evidence in order to optimise learning (Lindsley, 1992).

There are four foundation principles of PT: (1) The child knows best–in the sense that the child's response to a task or learning approach is the best indicator of whether the teaching method is working with that child; (2) Focus on observable behaviours–this is a practical rule so that accurate counts can be taken to monitor whether a child is improving in response to the current teaching method; (3) Use frequency measures to monitor performance–PT focuses on rate or frequency of responding which can only be measured using the number (or count) of correct and incorrect responses within a given timeframe; and (4) Use a standardised graphical display, the standard celeration chart (SCC), to record performance measures and make instructional decisions. These principles have been described in detail in a number of previous publications (e.g., Calkin, 2003; West, Young, & Spooner, 1990; White, 1986; White & Neely, 2004). Some of the key methodological characteristics we discuss here are: (1) element/compound analysis, (2) frequency-building, and (3) measuring learning or performance.

(1) Element/compound analysis refers to conducting an analysis of each compound (or complex) task in terms of what pre-skills, elements, or components, are required to carry out that task (Barrett, 1979; Binder, 1996; Haughton, 1972, 1980; Kubina & Morrison, 2000; McDowell & Keenan, 2001); in the current paper we will use the terms *elements* and *compounds* (Kubina & Morrison). Precision teachers state that one of the main reasons a person begins to experience problems in learning a task is because he or she is dysfluent at some of the prerequisite elements of that task. For example, if a child is dysfluent at decoding some of the basic sounds of English words, he or she will likely experience problems when reading novel words that contain those elements. According to Binder (1996) acquiring fluency in prerequisite key skill elements can improve the future learning of new skills that are dependent on these prerequisites.

(2) Frequency-building is a method used to develop both *accuracy* and *appropriate speed* in key elements (Binder, 1990, 1991). Being fluent at a skill has been described as "automatic", "effortless", "smooth" and "second nature" (Kubina & Morrison, 2000, p. 89). Accuracy at appropriate speed is vital in assessing performance levels because it is a significant indicator of expertise and therefore can help us discriminate between performers who have, or have not, mastered a skill (Binder, 2003; Chiesa & Robertson, 2000). For example, two children might score equally on an exercise using a percentage correct measurement system, but one of them

might have taken thirty minutes to complete the exercise and the other only five; it could be said that the latter child is more accomplished; however, when using percentage correct we cannot distinguish between levels of mastery beyond 100% accuracy. Despite this limitation percentage correct remains the prevailing unit of measurement in most educational settings. Frequency is the measurement system used in PT and refers to count in time, or the number of responses during a specified timeframe; in PT this is often 1 minute. This aspect of PT has its origins directly from one of Skinner's main contributions to the scientific study of behaviour: adopting *rate* (a synonym of frequency) as the basic datum of the science of behaviour.

Within the PT framework the objective is to move the learner toward skill mastery on specified curriculum sequences. When the learner reaches a fluent performance on a skill, particular *learning outcomes* are expected, such as, retention and application of skills and knowledge even in the absence of instruction. This list was later extended so that the learning outcomes of fluent performance included *retention*, *endurance*, *stability,* and *application*—captured in the acronym RESA (Fabrizio, 2004; Fabrizio & Moors, 2003; Johnson & Layng, 1992). According to Binder (1996) *retention* refers to "the relation between behavior frequencies at two points in time, between which the individual has had no opportunity to emit the behavior" (p. 164). The term *endurance* specifies how well a person can perform over prolonged periods of time (Binder, Haughton, & Van Eyk, 1995). Without endurance, pupils are unable to concentrate for extended periods, are increasingly likely to make errors, and are likely to perform negative emotional behaviours (Binder, 1996). *Application* has been described "as the convergent relationship of elements and compounds" (Kubina & Morrison, 2000, p. 92). And finally, *stability* refers to maintenance of performance in the presence of distractors (Lindsley, 1995).

(3) Measuring learning or performance. PT is fundamentally a method of measuring learning that can help teachers make timely decisions about the effectiveness of teaching for each child. Practice sprints or time probes are often used and offer an effective way of measuring a pupil's frequency or rate of performance on a particular skill. The child's performance might be measured for one minute, or alternatively, the time probes can be adapted depending on the complexity of the task. The count is nevertheless converted (either by division or multiplication) to give a count per minute (frequency or rate) score. The main point about these practice sprints is that they are a very efficient way of ensuring massed practice opportunities (aimed at building fluency) and allowing objective decisions about whether current teaching methods are improving learning (measuring student performance). As mentioned, PT involves the use of SCC to display performance data obtained from timed probes. The SCC has been described in detail in a number of previous publications (Calkin, 2003, 2005; Graf & Lindsley, 2002; Pennypacker, Gutierrez Jr., & Lindsley, 2003; White & Neely, 2004).

Informal testing often occurs implicitly within the day-to-day practice of teaching in many schools; however, the main way that PT differs from this is that the measurement probes are very short and precise, the teacher (or child) take data daily, and, importantly, use these data to make instructional decisions at least on a weekly basis. Over successive days of practice, the data (corrects and errors) plotted on SCC produce *learning pictures*. When used effectively these learning pictures can indicate, for each child, whether a task is too difficult, too easy, or just right; whether the child requires further instruction, further practice, or should move on to more complex tasks; and, most importantly, whether the teaching methods being adopted are having the desired effects. In short PT provides teachers with all the information they should require to make effective decisions about learning.

In this way the PT approach helps the teaching process become more effective in three ways: it becomes highly *reactive*–in the sense that teachers can identify learning problems as they happen for every child; it becomes *objective*–in the sense that the teacher knows precisely how every child is performing on the particular skills

they are practicing; and it becomes highly *individualised*–in the sense that very quickly each child is working only on skills upon which he or she require practice. These also help distinguish PT from accusations that it is similar to "drill-and-kill" and other outdated educational practices.

Thus optimal learning can be achieved through short frequent measurements that inform teachers about the learning progress of their students and guide them to alter learning strategies effectively until adequate progress is maintained. We describe the approach as *navigated learning*, because the teacher uses the information from these measurements to navigate the child through the learning sequence in the fastest way possible, in a similar manner to the way a captain of a ship uses a compass, or a coach helps an athlete improve performance.

Much research has confirmed the effectiveness of PT to improve pupils' academic performance. An example of this is research conducted by Chiesa & Robertson (2000). Five children underwent a twelve-week programme drawing on the principles of PT. Prior to the programme the five children were the lowest performers in the class on long division. They worked on elements of long division, practiced to build frequency, and progressed at individual rates through the programme; during these periods the rest of the class had a normal mathematics lesson. Following the programme the five PT children out-performed all but one of their peers on a test of long division despite having spent no time working on long division during the 12-weeks.

The Morningside Model of Generative Instruction (Johnson & Layng, 1992; Johnson & Street, 2004) is another example of the effectiveness of PT. This is a programme implemented at the Morningside Academy, Seattle, and uses PT on a daily basis to ensure children are learning rapidly and becoming fluent at key skills. Many pupils who attend the academy are typically labelled as having 'learning disabilities' or 'attention deficit disorder' when they arrive. Morningside report that over a 10-year span, pupils have consistently advanced during one academic year anywhere from one to almost four grade levels in reading, language, arts, and maths. This is especially impressive considering these achievements come from students who prior to attending Morningside were progressing at less than one year per academic year. In the UK, the *National Literacy Strategy* has recommended similar optimistic aims. They state that children who are behind in reading should be progressing at twice the rate of their peers to ensure there is a narrowing of the educational gap; if this kind of performance improvement is not achieved by the children, then the school should provide more effective teaching (DfES, 2003).

The current study explored the effects of a 10-week programme designed to increase the accurate word reading frequency with five pupils whose reading age was significantly below their average peers. The words targeted for this brief intervention were high frequency words that make up over 80% of children's literature (Maloney, Brearly, & Preece, 2001). These selected words, once learnt, will potentially enable pupils to engage with a broader range of reading materials. Very brief teaching interventions will allow teachers to assess whether PT techniques can be successfully implemented within a mainstream setting with children who have significant reading problems.

Method

Participants

Seven children (11-12 years old) participated; all were from a secondary comprehensive school in North Wales. The children were randomly assigned to either the PT intervention (n = 5); or treatment as usual (n = 2), who received the school's standard reading support during the allocated time. The ages of the PT children ranged from 11 years 6 months to 12 years 8 months (Mean: 12 years 2 months). The ages of the children who did not receive PT procedures (here known as the TAU children) ranged from 11 years 7 months to 11 years 11 months (Mean: 11 years 9 months). All seven children were selected because they were having significant problems reading and were receiving remedial support that took place in the school's

Supportive Studies classroom.

Prior to beginning the study, consent was obtained from the School Board of Governors, the head teacher, and the child's parents. Ethics approval was obtained from the School of Psychology Ethics Committee, Bangor University.

Setting

All seven children had been assigned a teaching assistant (TA) for the period—a 20-minute session, 3 to 4 times each week. The children attended the Supportive Studies classroom to participate in this study in place of attending the scheduled school assembly time.

Stimuli and apparatus

Digital timers were used to time practice sprints (e.g., 1-min, 30-sec timing periods). Error words were practiced using white-boards and non-permanent marker pens.

Other materials included standard celeration charts (SCC) and data recording sheets. The SCCs were used to record each child's best scores on a session-by-session basis. One data sheet was used to record all of the data for each session the child attended: date; name of the child; the skill being practiced; the aim (the frequency goal the child was aiming for); the score obtained for each time probe (for the number of correct responses and learning opportunities); length of each time probe (e.g., 1-min, 30-sec); and any comments, including the words read incorrectly within each practice session.

Instructional and testing materials

There were 2 types of instructional stimuli: word sheets and SAFMEDS (Say All Fast a Minute Every Day Shuffle) cards.

Word sheets. There were two word sheets: words 1-220 and 221-420. The first 1-220 words were obtained from the Dolch list (Dolch, 1948).The remaining 200 words were taken from the most common vocabulary words in English (Maloney, Brearly, & Preece, 2001), except for those already in the first 220 Dolch list. Each sheet contained a randomised list in Times font, size 14, double spaced, and were printed double-sided on A4 paper, with 110 words on each side. The randomised sheets were produced in Microsoft Excel©.

SAFMEDS. Initially we produced 420 SAFMEDS that were 9 x 4 centimetres in size and each had a common English word printed on one side. The words were the same as those used for the word lists previously described.

Each child had a folder that contained all the materials and sheets they required for their sessions.

Design and measures

The study used a single subject design were each individual child receiving the PT intervention was monitored on each practice attempt throughout the study. In addition, a number of measures of reading were taken prior to and following the intervention for the PT children in order to assess whether the reading practice would have effects on general reading ability as measured on the school's standard scales. The TAU children were also tested at the same points to monitor effects of the standard reading support over the same period of time.

In addition to being used to gain pre- and post-test scores, the information from these tests conducted prior to the intervention was used to select the children who participated. The two standardised tests used to select the children were the Group Reading Test II (GRT II) (NFER-Nelson, 2000) and the Vocabulary Scale of the Middle Years Information System (MidYIS) year 7 (CEM, 2007); both tests are standardised measures and are commonly used in schools throughout the UK. The GRT II is administered every 6 months; it measures both decoding and reading comprehension (see Table 1). The participants had been tested two months before the PT programme began and were retested one month after the PT programme ended.

For the purposes of this study we used the Vocabulary Scale section of the MidYIS test, which measures pupils' reading and vocabulary skills; the participants completed the year 7 version of this test to correspond with their year of study. The national average score for pupils of the same age is 102.3 and equates to a grade B on the Vocabulary Scale. The scores

Table 1. The Chronological Ages (Years:Months), Reading Ages measured using Group Reading Test II (GRTII), and the scores and grades on the Vocabulary Scale of MidYIS Year 7 tests for the PT (P) and Treatment as usual (TAU) children.

PT (P) TAU	Gender	Age (Y:M)	GRTII Reading Age (Y:M)	MidYIS (Year 7)	MidYIS Grade
P1	Male	11:04	7:03	77	D
P2	Male	11:05	6:09	89	D
P3	Male	12:05	6:10	80	D
P4	Female	12:06	<6:05*	83	D
P5	Female	12:03	<6:05*	67	D
TAU1	Male	11:09	<6:05*	79	D
TAU2	Male	11:05	6:07	75	D

*The test is unable to measure reading ages below 6 years 5 months.

for all 7 children on both the GRT II and the Vocabulary Scale of the MidYIS year 7 test reflected reading ages considerably below their chronological age.

To test for reading of words in real texts *(application),* three passages selected from books written for children between the ages of 7 and 9 were presented to each participant following the PT programme. Each passage was printed on A4 paper as they appeared in the books from which they came. The first passage, taken from *I Was A Teenage Goldfish* (Shipton, 1996; reading level 7-8 years), contained 224 words, 60% of which were in the 1-220 list. The second passage, taken from *Legendary Places* (Broker, 2000; reading level 8-8.5 years), contained 225 words, 60% of which were in the 1-220 list. The third passage, taken from *The Magic Boathouse* (Llewellyn, 1994; reading level of 8.5-9 years), contained 222 words, 62% of which were in the 1-220 list.

Procedure

The children attended approximately three 20-minute sessions a week over a 10-week period (excluding school breaks). During these sessions the PT children conducted timed practice sprints aimed at building frequency in reading common words. The TAU children were given the same time, and each supported by a teaching assistant (TA), to work on reading; during these sessions the children would pick a book and read this with the TA who was allocated to them. There was no other instruction given to the TAs working with the TAU children and the session typically comprised the TA listening to the child read, and correcting the child when they read words incorrectly. Beyond this we did not take any further measures on the TAU children apart from the standardised school tests as previously described.

For the PT children, on average, three time probes were taken per session (range 1 to 6). Each child sat at a separate table in the same classroom and worked with either a TA or a researcher. At the beginning of a typical session each child collected their personal folder containing their SAFMEDS cards, word sheets, charts, data sheets, and a digital timer.

During the programme, the child either read words from SAFMEDS or word sheets. These were alternated in the following order: SAFMEDS 1-220; word sheets containing words 1-220; SAFMEDS 221-420; word sheets containing words 221-420. SAFMEDS were split into smaller packs consisting of between 50 to 100 cards.

Phase I: SAFMEDS

Initially, each child was issued with the first pack of SAFMEDS. The AIMS for reading SAFMEDS was ≥70 correct with no more than 2 errors per minute (denoted as 70/2). Before commencing each practice sprint the child was reminded of the frequency aim and encouraged to 'try to get a personal best', or a 'PB'. In this manner the teaching quickly focused the reinforcement contingencies and the child's at-

tention on self-competition. This aspect of the PT approach encourages a child to experience success whatever their performance relative to others in the class.

The child was asked to read each card as quickly as possible, skip responses that were too difficult, and not to give up during a timing period. The child was asked to shuffle the pack and the timer was then set (to either 1 minute or 30 seconds). Usually the timings for each child began as a 1 minute timing and this was only altered to a different time period if he or she failed to progress. The child was then instructed to start reading once the timer had initially sounded and to continue reading until they heard the timer sound to signal the end of the timing period. As is common in PT procedures the child was provided with more opportunities to respond (words to read) than could be completed in the time period; in this way the procedure did not place an artificial ceiling, or Fluency Blocker (Binder, 1996), on the frequency of responses possible within the allocated time. The TA praised the child following all practice sprints.

During the practice sprint the TA or researcher instructed the child to place all words read correctly in a pile on his or her right hand side, and all the words read incorrectly or skipped (the child did not know how to read the word) in a separate pile on his or her left hand side. Within the sessions all incorrect responses were referred to as 'Learning Opportunities' or LOs.

For the error correction procedures, the TA wrote down all the LOs and the child practiced them for approximately a minute following each practice sprint. Error correction involved either decoding the word with the aid of the TA and then practicing this several times out loud, or, for irregular words, spelling and writing the word out on the child's white board and being required to read the word on each occasion.

Phase II: Word sheets

Once the child had reached the frequency AIM for the 220 SAFMEDS, he or she moved on to the word sheets that contained the same 220 words printed in a random order. The child read across the page from left to right as they would in reading a book. Each time the child attended a session he or she was issued with new randomised word sheets. The AIM range for the words sheets was 120-80 correct for three consecutive timings (Kubina, 2002). The TA had an identical sheet and followed the child as they read, marking any LOs with a pencil mark.

Data collection. Following each practice sprint, the child then counted the number of correct and LO responses (involving either SAFMEDS or a word sheet). Under the supervision of the TA, the child then recorded each score pair (i.e., number of corrects and number of LOs) on the data sheet and then charted the best score pair of that session on the corresponding calendar day on the SCC. (Each score pair was calculated as rate per minute before being charted on the SCC; for example, the score was multiplied by 2 if a 30 second time probe was used, so that all scores were displayed as count per minute data).

Learning pictures and decision criteria. The SCC presents a learning picture after several timings. The researcher assessed these daily in order to make decisions about progress. Different learning pictures revealed areas of strength and weakness, and allowed instructors to adapt instructional materials for each child accordingly. Thus, the programme was individualized dependent on the learning picture emerging from the child's daily performances over time (i.e., learning or *celeration)*. If the child was progressing and increasing the rate of reading we continued with the practice. If they were failing to progress we changed some aspect of the teaching, either the number of cards or the timing period was shortened (e.g., to 30 seconds). Children were moved on to the next learning task when they had maintained AIM across three successive attempts.

Measuring fluency

Fluency was measured following the 10-week programme by testing retention (PT children only), endurance, stability, and application; additionally all children completed the GRT II. The retention test occurred on the first

available opportunity between 5 and 9 weeks from the last day the child worked on word sheets containing the words 1-220. Endurance, application, and stability, were tested within three school days of the end of the teaching programme.

Retention. Retention was tested using the first 220 words from the Dolch list. Each child underwent two 1-min timings, and, as before, his or her best score was charted.

Endurance. Endurance was calculated as 3 times the duration of the typical time probes (i.e., 3 minutes). The child was presented with every word previously presented during the programme using three randomised word sheets. The child was required to read as many words as possible within 3 minutes without a break.

Stability. During this test the child read as many words as possible from a randomised word sheet containing words 1-220 in a busy classroom with a radio playing in the background for a 1-min timing.

Application. Each of the three passages chosen was suitable for a different reading level: 7-8 years, 8-8.5 years, and 8.5-9 years. The passages contained 224 words, 225 words, and 222 words, respectively. During the test, the child was instructed to read aloud each passage as if he or she were reading a book on their own; however, the child was not instructed to read the passage as fast as they could; the application tests thus varied in timing depending on how long the child took to finish the passage.

Inter observer reliability. We checked the reliability of the data in two ways. Decisions to move a child to a new learning task once they had reached their aim for that task were verified in the presence of a TA and one researcher. All of the tests for learning outcomes were double coded and inter observer agreement was calculated as 97.5% across all the tests.

Results

Individual data

All five participants' reading frequency of the selected words showed improvement over the 10-week intervention. Figure 1 shows a typical example of the daily best score pair (corrects and LOs) for a participants' reading performance during the PT programme and on post-programme fluency measures as plotted on a Daily per minute standard celeration chart. We used the SCC to monitor, or measure, the change in performance in response to the practice sprints.

Fluency measures

Pre- and post-measures of reading frequency. Figure 2 shows the difference between the participants' frequency scores obtained on the first day of the PT programme, their end frequency scores, and the highest score during the programme. For the PT children the end score was their retention score, and for the TAU children it was taken at the end of the teaching programme. It can be seen that each participant's reading frequency increased following the PT programme. With the exception of Participant 5, each participant read over twice as many words per minute during the maintenance test compared to his or her score obtained on the first day of the PT programme, thus demonstrating significant increases in rate when reading high frequency words, even following a period without direct practice opportunities. As can be seen from the data for the TAU children, engaging in their usual reading support had little effect on their reading rates of the high frequency words. Generally, the PT participants who produced higher rates of correct responses during the programme produced higher rates of correct responses during the retention test, except for Participant 4 who scored higher than Participant 3 on the test.

Endurance. Table 2 shows the correct and LO frequency obtained during the 3-minute endurance test. With the exception of Participant 4, the children who obtained higher frequencies of word reading during the PT programme also obtained higher frequencies during the endurance test.

The PT children read, on average, 4 times more words correctly per minute than the TAU children during the endurance test. The PT children also read at a faster rate relative to the TAU children: PT children read between 57.3 and 110.7 correct responses per minute (range

53.4), whilst in comparison TAU children read between 17.7 and 28 correct responses per minute (range 10.3). Even though the PT children read faster, their error rates were still lower than the TAU children. The TAU children read at a slow rate relative to the PT children but also made many errors: PT children obtained between 0.2 and 4 errors per minute (range 3.8), whilst in comparison TAU children read between 4.7 and 38.7 errors per minute (range 34.0).

Stability. The children who obtained higher frequencies during the PT programme attained more stable learning on the test. The PT children read, on average, 5 times more words correctly during the stability test than the TAU children. The PT children also read at a faster rate relative to the TAU children. With the exception of Participant 2, the PT children made fewer errors than the TAU children even though they were reading faster: PT children read between 76 and 116 correct responses per minute (range 40) whilst the TAU children read between 2 and 37 correct responses per minute (range 35). PT children obtained between 0 and 7 errors per minute (range 7) and the TAU children read between 5 and 47 errors per minute (range 42).

GRT II. Pre-programme GRT II scores reflected reading ages ranging across the participants from below 6:05 (years:months) to 7:03 (see Table 2). Mean scores for the PT children increased from 6:09 (a precise pre-programme mean score is prevented due to the

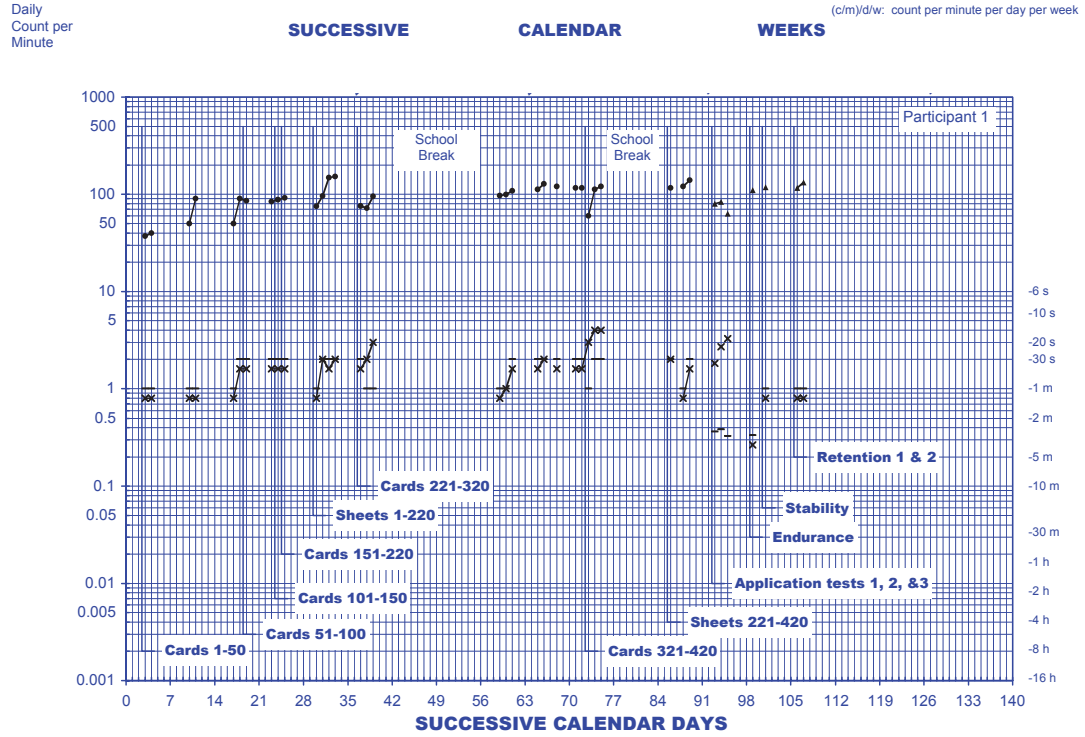

Figure 1. A daily per minute standard celeration chart showing the best daily score pairs for Participant 1. The Y-axis indicates frequency (count per minute) on a multiply-divide scale ranging from .001 per minute (1 in 16 hours) to 1000 per minute. The X-axis is a calendar scale indicating day 1 – 140. Correct responses per minute are denoted by dots and incorrect responses by Xs. The black dashed lines (-) represent the counting period (timing floor) and denote the length of the practice sprint: a line on the '1' indicates the counting period is 1 minute; a line on the '2' indicates the counting period was 30 seconds (i.e., 2 x 30 seconds in 1 minute). All data were based on count per minute data. A score below the counting floor represents zero responses.

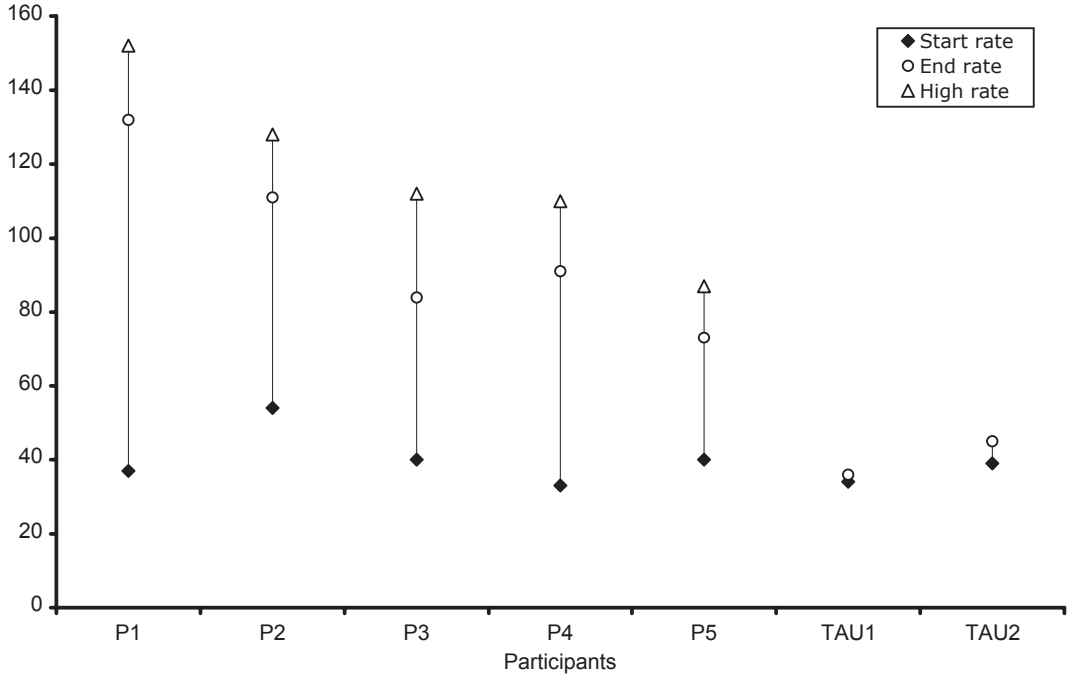

Figure 2. For each participant (P = PT; TAU = Treatment as usual) the fluency scores (correct only) for the start rate, the end rate, and for the PT children only, the highest rate achieved during the intervention.

test's inability to measure a reading age below 6 years 5 months) to 7:00 post-programme. If Participant 1 is excluded from the analysis, the PT children would have increased on average from 6:08 to 7:01. The TAU children's mean reading age actually decreased from 6:07 to 6:06, or below. The PT children's mean reading age increased by at least 3 months, or 5 months if Participant 1's scores are excluded. In contrast, the TAU children's mean reading age decreased by at least 1 month.

Application tests. These texts were previously unseen and contained approximately 60% of the words that had been targeted during the

Table 2. Shows for the PT (P) and Treatment as usual (TAU) children, the correct and LO rate scores on both the endurance and stability tests (corrects/ LOs), the GRT II scores reflecting reading ages at pre- and post-programme (years:months); and, for the five PT children only, the number of practice sprints, the total active time (hours:minutes), and the average active time per week (minutes).

PT (P) TAU	Endurance (corr./ LOs)	Stability (corr. / LOs)	Pre-GRT II (Y:M)	Post-GRT II (Y:M)	No. practice sprints	Total time (hr:min)	Av. time / week (min)
P1	110.7/0.2	116.0/0	7:03	6:10	91	2:37	16
P2	96.7/3.3	107.0/7	6:09	7:09	62	1:50	11
P3	70.7/1.3	90.0/1	6:10	6:10	81	2:29	15
P4	92.0/1.0	87.0/4	<6:05*	7:01	43	1:17	8
P5	57.3/4.0	76.0/2	<6:05*	<6:05*	61	1:45	11
TAU1	28.0/4.7	37.0/5	<6:05*	<6:05*	–	–	–
TAU2	17.7/38.7	2.0/47	6:07	<6:05*	–	–	–

*The test is unable to measure reading ages below 6 years 5 months.

PT programme (Tests 1, 2, and 3 comprised 60%, 60%, and 62% of the words presented in the PT programme, respectively). Figure 3 highlights the difference between the PT and TAU children when we isolated the words that had been targeted in the PT programme for frequency building, termed *target words*. Figure 3 shows both correct *and* incorrect responses for target words included in all three tests. The PT children read all words previously presented in the PT programme correctly (see Figure 3), except for Participant 5 who read one of these words incorrectly (the word *saw*). In contrast, the TAU children read 370 target words incorrectly. TAU Participant 1 read 17%, 9%, and 15% of these words incorrectly on application tests 1, 2, and 3, respectively. TAU Participant 2 read 60%, 74%, and 51% of these words incorrectly on application tests 1, 2, and 3, respectively. Thus the PT children showed they could read these words when they occurred in the context of a novel, age appropriate text.

Figure 4 highlights the difference between the PT and TAU children when we isolated the words that had been not been targeted, termed *non-target words*. Application tests 1, 2, and 3 contained 40%, 40%, and 38% of non-target words, respectively. The PT children made more errors (LOs) when reading non-target words than target words. Participant 3 obtained the most number of LOs for non-target words, reading 11%, 13%, and 23% of them incorrectly on application tests 1, 2, and 3, respectively. The TAU children obtained, on average, 15, 10, and 8 times more LOs for *all* words per minute on application tests 1, 2, and 3 respectively than the PT children. The PT children read at a much faster rate than the 2 TAU children, yet their error rate was considerably lower.

Time engaged in intervention. The amount of time each PT participant spent engaged in the programme was calculated by adding the total duration of time each pupil carried out time probes to the total number of time probes they undertook (assuming for each time probe taken, that a minute was spent practicing LOs; see Table 2). The average weekly time spent engaging with the targeted words was 12 min-

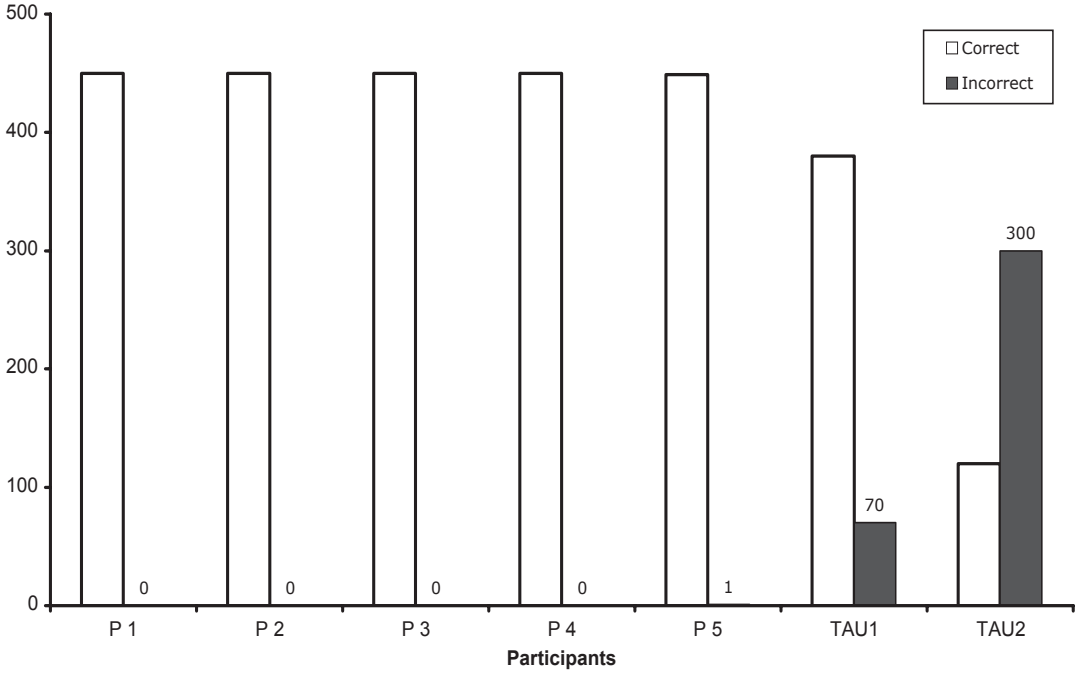

Figure 3. Number of target words (i.e., those covered in the PT reading programme) read correctly and incorrectly by each of the seven participants (P = PT; TAU = Treatment as usual) across the three application tests. (NB: Y-axis scale is from 0 -500).

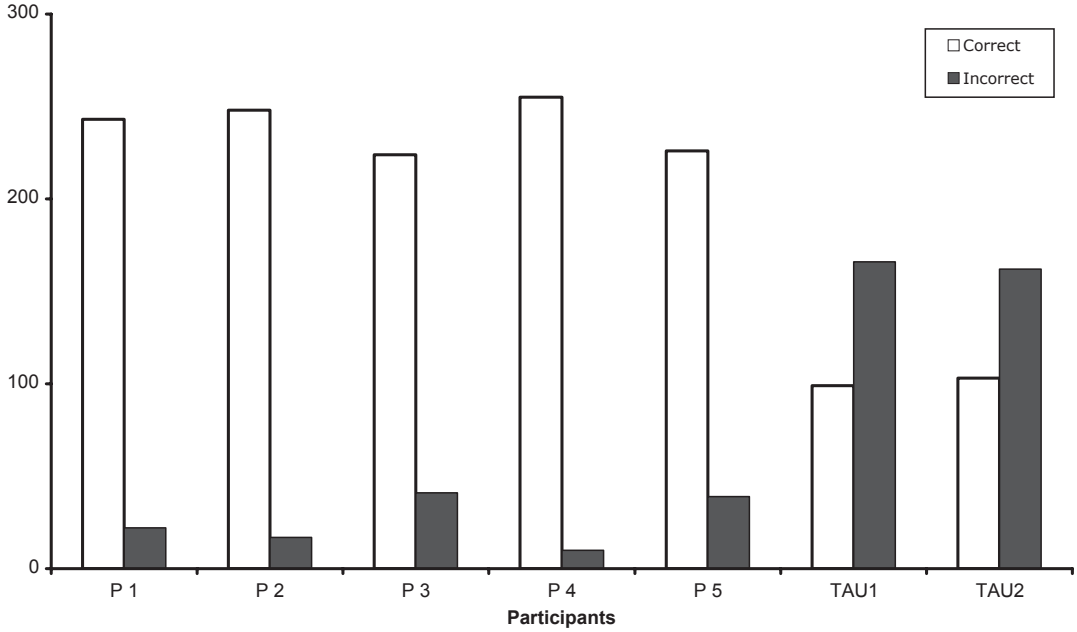

Figure 4. Number of non-target words (i.e., those not covered in the PT reading programme), read correctly and incorrectly by each of the seven participants (P = PT; TAU = Treatment as usual) across the three application tests. (NB: Y-axis scale is from 0 -300).

utes (range 8 to 16 minutes) per week for 10 weeks. Participant 1 spent the most time actively engaged with the PT words. This participant also obtained the highest frequencies on the retention, application, endurance, and stability tests, and achieved the highest frequency during the programme.

Discussion

The aim of this study was to evaluate the effectiveness of a brief intervention using practice sprints and PT procedures to increase the reading frequency of common words. All seven children in the study read significantly below their average peers and were at serious risk, not only of experiencing continuing problems in reading but also facing future academic failure. Both the PT and the TAU children worked on reading skills for the same amount of time during the study. The difference between the two was the type of reading activities engaged in during the sessions: the PT children concentrated on frequency-building exercises with common words and self-paced progression (based on decisions made by the researchers analysing each child's progress using the SCC), while the TAU children received standard one-to-one reading support from a TA.

For all seven children we took measures both pre- and post-intervention on frequency of reading the Dolch list words, standardised measures using the GRT II, and measures of endurance, stability, and application. Additionally, for the PT children only, we measured the active engagement time, and retention of their reading frequency approximately five weeks after they had initially reached frequency aims on the Dolch list words.

All of the PT children increased their reading word frequency on the target words significantly, thus demonstrating that brief practice sprints offer an effective, efficient, and easily administered procedure for helping children with significant reading problems. The increase in frequency also resulted in concomitant improvements on outcome measures of fluency. Indeed, from the measures we took the interven-

tion seemed to have positive effects on all aspects of reading performance. The data from our TAU children, who received their standard form of reading support seemed to show little effect on their reading frequency; this of course may have been expected for two reasons: first, because this is the form of reading experience that they had been exposed to prior to the study and it had obviously not been successful for them; and second, the standard teaching approach, as with many schools, did not focus on short practice sprints that concentrate on building rate of reading high frequency words.

The application tests consisted of prose taken from real books and were designed to test real life reading skills. When we analysed the difference between the PT and TAU children on their success on reading both the target words and non-target words we found that the PT children read almost every target word correctly in real prose; on average the TAU children read only 69% of these words correctly. For the non-target words, this difference in error rate was also evident; the PT children made significantly fewer errors on non-target words than did the TAU children, who were clearly struggling to read material graded for children from 7 – 9 years old.

When we compared how the children did across the two groups of words we found that the PT children made many more errors on the non-target words than they did on the target words. We could speculate why this may be the case. One possibility is that the non-target words were more difficult to read than the target words and thus we would expect this disparity, especially given the problems these children were having with reading. It was certainly the case that the non-target words were relatively less frequent in reading material. However, the data from the TAU children would suggest this is not a clear cut issue because they had made a similar percentage of errors on both target and non-target words. It seems likely then that the reason the PT children could read the target words is simply because they had learned and practiced them.

A second possibility is that children who are able to read the most frequent words fluently would find reading in general easier than those who struggled even to read common words that appear regularly in prose (e.g., where, because, while). It may have been that the PT children had started to engage more with the reading process in general. Indeed, anecdotal written reports from the TAs who supported these children had listed that Participant 2 and Participant 4 had noticeably improved their reading skills in other lessons, and Participant 4 had volunteered for the first time to read aloud in her regular classroom. The benefits of such a programme to children struggling to acquire reading skills are evident in the tables and figures presented in this paper. However, they do not show the PT participants' changing relationship to their reading as the programme progressed. Before the programme's commencement, it was evident from both witnessing the children reading and from their reading scores on standardised tests that their reading was extremely poor, and that engaging with reading materials was difficult and frustrating for these children; such conditions are likely to establish escape and / or avoidance of reading as a powerful reinforcer.

When we consider how this intervention may have had its effect, there are five issues. First, the procedure focuses the child onto small manageable units of information to be learned. In this way it may help to make the learning situation less aversive for children who have a long history of failure with reading and more generally within the school setting. Second, because frequency-building gives the opportunity for massed practice it gives children with learning issues time to practice–time that the normal classroom pace would not typically allow. These procedures thus encourage high active student responses (Barbetta, Heron, & Heward, 1993). Third, the PT procedures encourage self- rather than peer-competition; for children who are struggling to learn it can be a liberating experience not to be compared, either explicitly or implicitly, with other often more successful peers. Fourth, the PT procedures adapt to an individual child's learning and so ensure that the child is making progress and not stagnating without improvement—this is motivating

for both the children and their teacher. And finally, the teaching procedures themselves are different from those the children had previously experienced; they require high levels of activity, children could follow their daily progress on their charts, and they were motivated to beat their own previous personal best scores. They also enjoyed using the SAFMEDS cards as an alternative learning channel for practicing.

The GRT II results concluded that the PT children's mean reading age had increased by 3 months (or 5 months if we exclude Participant 1 from the analysis). In contrast, the TAU children's mean reading age decreased by at least 1 month. Participant 1 was the only child from the PT children whose score decreased on the GRT II standardised reading test. This was an unexpected result because he had obtained higher reading rates than any other child in the intervention. Anecdotally, the teachers had noticed a recent fall in the child's commitment to school and the verbal reports of the tester confirmed that he had not engaged with the test. Whatever the reason for his decrease in scores on the standardised reading tests, this decrease was at odds with both expectations and his demonstrable increase as measured on the other outcome tests.

Further benefits of the PT programme include the minimal time and materials required for its implementation. Raybould and Solity (1988) noted that PT procedures may turn out to be costly both of time and resources. However, the present study suggests that a brief intervention using PT techniques can be very effective in terms of enabling learning but relatively inexpensive in terms of the resources required in both time and materials. The children spent, on average, only 12 minutes per week engaged with the targeted words. The only resources required were straightforward to prepare. These comprised data sheets, word sheets, and SAFMEDS. Master copies were filed, and could be recopied for later use with other children. Other studies support these findings, reporting that frequency-building procedures increase teachers' instructional time, not reduce it (Beck & Clement, 1991; Kubina & Morrison, 2000). In addition, frequency training has been reported to ensure retention, endurance, application of skills and knowledge even in the absence of instruction (Binder, 1996). These outcomes are all likely to reduce teachers' time requirements: relearning, refreshing and reteaching would be necessary if such skills were not retained.

One of the limitations of this study was that we only tested for application of these skills post-intervention; it could be argued that there may have been significant differences between the PT and TAU children prior to the intervention. We decided not to test for application prior to the study because these children were finding reading normal texts of this level extremely challenging and aversive at that point—our primary goal was to first create the space where they could begin to succeed with reading.

Although we talk here of the differences between the PT children and the TAU children there are a number of possible confounds in the present study that would require further research to clarify. We have mentioned that the TAU children received the standard school reading support for the same *time* as the other children were conducting frequency-building practice. From this data we can say that the TAU children did not improve their reading as measured on the tests included here and with the reading instruction they received (i.e., 20 minutes a few times per week for 10 weeks). However we do not have data on the type of learning experience they received during this time. For example, we do not have information on the response rate during these sessions, the rate of reinforcement, or the type of instruction. It could be the case that the children in the PT intervention received higher rates of reinforcement and conversely the TAU children may have been exposed to aversive conditions associated with a high effort task. In fact this is highly probable. It is thus difficult for us to directly compare the PT children to the TAU children systematically because we did not control or document the experience of the children in the treatment as usual condition. This should be a consideration of future research.

We also need to make clear that this is not a comparison study that sought to compare

treatment under one condition with treatment under another, typical of a between group comparison design. This was clearly a single subject design study that used multiple individuals and examined the individual children across the 10-week study. In this case the individual children acted as their own control and the pre- and post-scores across the various measures should be taken on an individual basis. And lastly, because the numbers in the present study were small we cannot say with confidence that the TAU children were similar to the PT children on variables important in reading. What we can comment on is the difference of each child on the pre- and post-tests and how this difference correlates to the particular experience they received.

The data we present here suggest that those children who achieved the highest frequencies of word reading during the intervention were also the children who tended to score highest on our outcome tests of RESA (or fluency). We could conclude that this is evidence that higher frequencies lead to better learning outcomes; however, in the present study we did not control for the number of practice opportunities that each child had. Therefore it is difficult to tease apart whether the important factor in better learning outcomes is rate *per se,* or more opportunities to practice a skill.

Doughty, Chase, and O'Shields (2004) recently initiated a new dialogue about the relationship between rate building and the outcomes of fluent performance (RESA). They argue there is insufficient empirical evidence to support claims made by precision teachers because previous research has not adequately controlled for either amount of practice or rate of reinforcement. From the ongoing debate a number of recommendations have emerged for the design of future research (Binder, 2004; Chase, Doughty, & O'Shields, 2005; Kubina, 2005). Further research is required to compare learning outcomes following frequency-building procedures with pace-restricted or discrete trial procedures that have the same number of opportunities to respond. However, such research would have to test whether the pace-restricted learning condition had enabled learners to become fluent as an outcome of the learning procedure prior to testing for RESA (Binder, 2004; Johnson & Street, 2004). At present the limited research that has compared the two learning approaches has not controlled for this confound (Bucklin, Dickinson, & Brethover, 2000; Kim, Carr, & Templeton, 2001). Additionally, further research should also examine latency between the presentation of a stimulus and the response from the learner to ascertain whether pace-restricted learning procedures result in a significant reduction in response latency, and thus the potential to respond at a high rate under situations where the discriminative stimulus is not restricted by the instructional procedures; that is, under free operant conditions where there is freedom to present stimuli and freedom to respond from the learner (Barrett, 2003).

The current study involved five children in the intervention who were between the ages of 11 and 12. There is a need to replicate this form of short intervention because it represents an efficient and procedurally straightforward way to help children build frequency on reading words. The procedure should be extended to different age groups and may be a timely intervention for those children who are beginning to show evidence of reading problems earlier in primary education.

The words selected for this research were the 1000 most common in reading literature, and make-up over 80% of all reading literature (Maloney, Brearly, & Preece, 2001). During the brief intervention the children covered between 220- 420 of these words. If the same level of teaching had continued, we could speculate that these children could have achieved good fluency levels with all 1000 targeted words in a period of between six to eleven months (P1 in less than six months; P2, P3, and P4 in less than eight months; and P5 in less than eleven months). We could further speculate that if they had received the same level of frequency-building procedures for approximately 20 minutes per day each school day, as opposed to a few times per week, we may have expected them to achieve these levels in a period of between four to six months of teaching. We could speculate that a child who

is fluent with at least these words, and who had a speaking and listening vocabulary (i.e., understood these words in normal conversation), could successfully negotiate many of the reading tasks required both in and outside of the school environment. This of course will require further research to corroborate.

The significance of the improvement made in the time we had to work with these children should not be underestimated in the context of the goals of this research and the children we sought to help. The children selected for the intervention were experiencing or at serious risk of academic failure and all the concomitant risk factors correlated with this outcome. They were also at a crucial age were illiteracy was an extremely serious situation that effectively prevented them from engaging with the rest of the academic curricula.

This 10-week PT programme was designed to increase the reading skills of 5 pupils with specific reading difficulties. Despite the very brief teaching intervention, each PT child increased reading frequency on targeted words significantly and demonstrated they could read these words when tested under normal reading conditions. This study not only demonstrates the effectiveness of PT and frequency-building procedures, but also that simple learning procedures with a long history of research evidence can enable students, who have previously failed to learn the most crucial academic skill in the standard educational settings, to learn and succeed.

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