BEHAVIOURAL FLUENCY FOR YOUNG CHILDREN WITH AUTISM

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This thesis is presented for the degree of Doctor of Philosophy of Murdoch University, 2002
DECLARATION

I declare that this thesis is my own account of my research and contains as its main content work that has not previously been submitted for a degree at any tertiary education institution.

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David J. Bonser
Fluency is functionally defined by: skill retention after a period without practice; skill endurance over longer intervals than encountered during practice; skill stability in the face of distraction; a performance that can be effortlessly applied to new environments; and a skill that adduces easily with other skills to form new repertoires (RESAA). Precision Teachers have found that fluency can be promoted by building the frequency of an accurate response to high rates. Young children with autism often fail to achieve RESAA outcomes from accuracy-based discrete trial training and may benefit from frequency-building instruction. However, a lack of published empirical support has meant that many behavioural educators have resisted adopting these strategies. The purpose of the current study was to determine if frequency-building procedures will promote the fluent skill development of tasks encountered on many early intervention programs for 12 young children with autism. The data showed that imitation, line tracing, drawing, simple addition, and phoneme reading skills taught to young children with autism achieved RESAA outcomes and responded to frequency-building procedures in ways that were consistent with non-autistic populations. Secondly, frequency-building imitation to a rate-based fluency aim produced far greater gains on measures of generalised imitation than using discrete trial training to an accuracy-based mastery criterion alone. Thirdly, increases in the rate of performance under frequency-building conditions positively predicted increases in the quality and quantity of applications, adductions, and skill generalisation for most skills. Fourthly, more exemplars are preferable to few during frequency-building practice. Fifthly, gross motor imitation, a controlled-operant task by definition, was
modified and practiced to rates high enough to achieve RESAA criteria. Finally, discrete trial training was as effective as frequency-building when matched for reinforcement and practice, however was less efficient and rated less enjoyable by 5 children without developmental disabilities. The findings were consistent with behavioural fluency predictions and support the inclusion of frequency-building strategies to promote skill fluency for young children with autism.
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INTRODUCTION

The problem of skill generalisation

Achieving skill generalisation away from the training setting is critical to the success of any early intervention program. For example, when a trainer successfully teaches a young child with autism to imitate some gross motor movements, she will also want that child to imitate other untrained movements as well. Plus, she will also want new behaviour to occur in any number of other settings and situations. Broadly defined generalisation is when a response occurs in the absence of specific training stimuli. If skills generalise with little to no direct teaching, then valuable teaching time has been saved and we gain a lot more for our teaching efforts. Of course sometimes an unwanted generalisation occurs. An example of an unwanted generalisation is when a child learns to call his father “daddy” but then calls all men “daddy”. Nevertheless, most of the time, the focus of educators and behavioural programmers is to maximise generalisation across responses, across stimuli, and over time. Promoting generalisation with children with autism has often been difficult to achieve (Koegel & Rincover, 1977; Powers, 1992). In their seminal analysis of skill generalisation Stokes and Baer (1977) provided a conceptual framework for promoting generalization and maintenance. Based on their review of 270 published studies in applied behaviour analysis they showed that training skills up to accuracy and hoping for generalisation was a popular, but extremely ineffective practice. As a solution, they presented 8 programming tactics for optimising skill generalisation. These were:
1. The gradual and sequential modification of procedures or stimuli from the training setting to nontraining settings.
2. To introduce natural maintaining contingencies and shift stimulus control from the training procedures to naturally occurring stimuli.
3. To train sufficient exemplars of a desired response or stimulus using a wide range of positive examples.
4. To train loosely by deliberately varying the stimuli and responses reinforced during training.
5. Employ indiscriminable variable ratio schedules of reinforcement during training.
6. To program common discriminative stimuli in both training and nontraining settings.
7. To use language, written text, symbols, and other prompts to mediate skill generalisation across settings.
8. To train “to generalise” by treating generalisation as a target behaviour and reinforcing its occurrence.

Haring, Liberty, Billingsley, White, Lynch, Kayser and McCarty (1985) noted that most interventions still maintained a train and hope approach to skill generalisation. The authors noted that this finding was disappointing considering that Stokes and Baer (1977) had published almost a decade earlier. During the 1980s efforts continued towards a comprehensive technology of generalisation (Stokes & Osnes, 1989; White, Leber & Phifer, 1985). Although overtraining had shown some promise with non-autistic populations, Greenspan and Wieder (1997) and Romanczyk (1996) showed that overtraining failed to promote
reliable skill generalisation for many children with autism. However, another potential solution to the generalisation problem may come from the application of fluency-based strategies (Binder, 1988; 1993; 1996; Johnson & Layng, 1992; 1994; 1996; Kubina & Morrison, 2000; Lindsley, 1990; 1991; 1992; 1996a; 1996b; 1996c; Maloney, 1998; Weiss, 2001). Over the last 5 years there have been poster presentations, discussion papers and short reports that suggest fluency-based training may benefit the young child with autism (e.g. Bonser & Leach, 1997). Similarly there is some evidence from centre-based applications that these methods can assist young children with learning disabilities, developmental disabilities, and autism (Binder & Watkins, 1990; Fabrizio & Schirmer, 2002; Johnson & Layng, 1992; 1994; Malabello, 1998; Maloney, 1998; McDowell & Keenan, 2001; Mercer & Mercer, 1993). However the purpose of these centres is to improve the skills and knowledge of their students, often by combining many different instructional strategies, and not to conduct well-controlled research (i.e. systematic manipulation of independent variables with baseline reversals and accurate descriptions of replicable procedures). The purpose of this study is to provide an experimental analysis of frequency-building, a component used by most fluency-based training programs (Johnson & Layng, 1996). The rationale for this study is to determine if frequency-building procedures are a viable solution to the problem of skill generalisation for young children with autism. Based on this rationale the main aim is to determine if imitation, tracing, drawing, simple addition, and phoneme reading skills taught to young children with autism, with no previous experience with frequency-building procedures, can achieve and maintain generalised outcomes and respond
to frequency-building procedures in ways that are consistent with non-autistic populations.

Fluency defined

Fluency is synonymous with terms such as proficiency, flowing and effortless. When used to describe a performance, fluency tacts demonstrations of knowledge and skill that generally arise only after much dedication and practice. In the context of an experimental analysis, fluency describes self-paced behaviour that is both highly accurate and can be performed at a very high rate. Furthermore, fluent behaviour retains after a period without practice, endures over longer intervals than encountered during practice, shows stability in the face of distraction, is effortlessly applied to new environments, and may easily adduce with other behaviour to form new repertoires. The acronym RESAA (retention, endurance, stability, application and adduction) describes these outcomes (Johnson & Layng, 1996). Lindsley (1996b) suggested “…the effects define fluency in the same way that the effects define reinforcement…” (p.212).

However, this is not entirely accurate because reinforcement can be introduced or removed from a procedure at any given moment and the effects can be measured. Fluency, on the other hand, has no effects because the outcomes could also be attributed to its causes. Similarly, it would be impossible to introduce fluency and then remove it the next day. Fluency best describes a set of outcomes the same way a syndrome describes a set of symptoms. In the same way diagnostic criteria enable physicians to label a syndrome; RESAA is a set of outcomes that determine whether a skill should be labelled fluent. Fluency has also been used
to describe a body of mostly field-based research referred to as **behavioural fluency** (Binder, 1993; 1995; 1996; Johnson & Layng, 1996).

Fluency has often been compared to gaining expertise through practice (Anderson, 1982; Dempster, 1988; Dempster & Farris, 1990; Newell & Rosenbloom, 1981), automaticity (LaBerge & Samuels, 1974; Robbins, 1994; Schneider & Shiffrin, 1977), mastery (Bloom, 1986) and overlearning/overtraining (Baldwin & Ford, 1988; Dougherty & Johnston, 1996; Hagman & Rose, 1983; Judd & Glaser, 1969). Although the mastery learning, automaticity and overlearning literature describes similar outcomes, fluency can be distinguished by self-paced practice and rate sensitive measurement strategies, fluency-based frequency aims, and hierarchical analyses of basic skills and composite performances.

**Fluency and Precision Teaching**

The concept of building skills to fluency was born out of the application of Precision Teaching. Prior to developing Precision Teaching, Lindsley (1962) had begun using rate-based data recording as part of his research with hospitalised populations. He had observed that the curve or slope of the data he recorded allowed an immediate analysis of the effects of his interventions. He also observed that frequency could be 10 to 100 times more sensitive than percentage correct scores for detecting these changes (Lindsley, 1972; 1991). In 1965 a group of remedial classroom teachers approached Lindsley because they needed a highly sensitive decision making tool to assess the effects interventions
and teaching had on the behaviour of their students. The more commonly used percentage correct scores had resulted in one-dimensional interpretations of performance and often failed to discriminate between sometimes very different performances (Binder, 2001; Lindsley, 1996d; 1999). For example, teachers found that a student who scored 30 out of 50 math problems correct in 2-minutes (15 corrects and 10 errors per minute) usually required a different intervention to improve his performance than a student who scored 30 out of 50 correct in only 30-seconds (60 corrects and 40 errors per minute). Percentage correct descriptions were ineffective because they masked these crucial differences by showing that both children scored 60% correct. It was from this need that Precision Teaching was born. Lindsley (1971) found that the highly sensitive frequency-based measures permitted students and teachers to determine the effects and outcomes of the procedures they were using with greater precision than ever before (Binder, 2001; Lindlsey, 1996d; 1999). The standard celeration chart (see Figure 1.1) was later developed as a standardised means for presenting frequency-based measures and for improving communication between teachers (Lindsley, 1971; Pennypacker, Koenig, & Lindsley, 1972). On the chart the vertical axis is on a logarithmic (multiply) scale whereas the abscissa is on a linear (add) scale. The log scale ranges from 0.001 counts per minute up to 1000 counts per minute; the linear scale spans 140 successive calendar days. Precision Teachers use the chart within their lessons to “…teach-measure-decide-teach-measure-decide…” (Howell & Lorson-Howell, 1990 p.21). A unique and serendipitous discovery came from viewing thousands of standard celeration charts which consistently showed that learning curves were transformed into straight lines when displayed on semi-logarithmic charts (Binder, 1996, 2001;
Koenig, 1971; Lindsley, 1999; Pennypacker et al., 1972; West, Young & Spooner, 1990). Most importantly, this finding allowed frequency data to be analysed and described across 3 dimensions (count per minute per week) – on a power (times itself) scale (Lindsley, 1996c). This 3 dimensional unit measure was named celeration – a name based on the root word of “ac-celeration” and “de-celeration”. For example, a behaviour frequency that tripled in one calendar week was called x3 celeration. Similarly, a behaviour frequency that halved in one calendar week was called a ÷2 celeration. Binder (1996; 2001) has suggested that celeration is the quickest and most effective measure of learning that currently exists.

The advantage of multiply/divide measures is that they retain the proportions, or symmetry, of the actual behaviour change that took place (Binder, 2001; Lindsley, 1999). For example, consider a learner whose rate climbs from 10 per minute to 15 per minute in one week, and then drops back down to 10 per minute the following week. If these changes were described using percentage measures we would say his rate jumped by 50% during the first week and then fell by 33% the following week. Although the changes, in absolute terms, were symmetrical (he gained 5 per minute one week and lost 5 per minute the next), percentage descriptions lose, or mask, this symmetry. However, using multiply/divide descriptions, we would say his rate showed x1.5 celeration (rising from 10 to 15) during the first week and a ÷1.5 celeration (dropping from 15 to 10) during week two. By using multiply/divide descriptions we can retain the symmetry of these changes. In the current thesis multiply and divide descriptions of behaviour change will be used as part of the analyses and to describe significant changes in
performance. A Microsoft Excel version of the standard celeration chart was designed for the current thesis and information about how to read this version is presented in Figure 1.2. Readers familiar with standard celeration charts will see that there have been relatively few changes and should have no problems reading the charts presented here.
Figure 1.1. The standard celeration chart (from Maloney, 1998 p.121).
Figure 1.2. This sample chart explains the charting protocols and conventions used in this study.
Initial applications of Precision Teaching focused on the continuous measurement of behaviour throughout an entire class session. However, Eric Haughton was able to demonstrate to Lindsley that 1-minute timings were sufficiently sensitive enough to predict performance over much longer intervals (Haughton, 1972; 1977; 1980; Lindsley, 1989; 1971; 1996b). The concept and benefits of fluency arose from applying these 1-minute assessments and was primarily developed by Eric Haughton and his colleagues (Binder, 1993; Haughton, 1971; 1972; 1977; 1980; 1981; Lindsley, 1992; Maloney, 1998; Starlin, 1970). Using brief, timed assessments Haughton (1972), Starlin (1970), Maloney (1998) and Kunzelmann and colleagues collected data on student’s performance rates for more than 3,000 skills (Mercer, Mercer & Evans, 1982). Following significant breaks in practice students were assessed again and the data showed that students, who could perform above certain rates prior to the break, had retained their skills. For example, students who could read at rates greater than 200 correct words per minutes when timed for 1-minute retained this speed and accuracy after the break. Students with lower rates suffered skill deterioration with the lowest performers resulting in the greatest loses (Maloney, 1998).

Precision Teachers began using these critical rates as frequency aims for their teaching programs and began using the term fluency to describe behaviour that reached these rates (Haughton, 1972; 1980; West, Young & Spooner, 1990). This work has subsequently been built upon by thousands of chart shares (Koenig, 1971) and some published papers (Freeman & Haughton, 1993a; 1993b; Binder, 1993; 1996; Johnson & Layng, 1996; 1994). Haughton (1980) suggested
that these frequency aims are really a range of frequencies that can account for the development of fluency for most learners.

Johnson and Layng (1996) recently suggested that there were at least 3 ways of setting frequency aims. One involved probing the rate at which the average learner of the same age could perform the skill. Another method involved probing the rate at which a same aged expert could perform the skill. The third method involved probing the rate at which an adult (older expert) could perform the skill (Haughton, 1972). Some of the frequency aims used in the current thesis (e.g. gross motor imitation) were derived using this third method. Although frequency aims initially helped teachers and students overcome the problem of skill retention, Precision Teachers noticed that there were many other pay-offs for reaching fluency and now use the term RESAA to describe these outcomes (Binder, 1996; Johnson & Layng, 1996; Kubina & Morrison, 2000). Each of these outcomes will be reviewed later in this thesis.

Precision Teachers also noticed different response forms (outputs) require different frequency aims. For example, say responses required higher frequency aims than writing responses (Haughton, 1971; 1972; 1980). Later, Precision Teachers introduced the concept of learning channels as a means to quickly describe and translate how discriminative stimuli were perceived by the learner (input) and how the learner responded to the stimuli (output). Learning channels describe the antecedent-behaviour relationships and economically translate teaching procedures for easy replication. For example, if a learner is given a sheet of addition problems and then is required to write the answers to each of
the problems, this task uses the see-write learning channel. Alternatively, the learner could be given the same sheet of problems and be asked to call out the answers to the problems. In this case the learning channel is see-say. Furthermore, if the teacher read out the problems to the learner and he was required to say the answers out loud then the learning channel is hear-say. Keller (1978 cited in Lindsley, 1990) found that by targeting the same skill through multiple learning channels learning rates could be improved. In this sense, training a task on two learning channels, rather than one, improved learning. Maloney (1998) further noted that changing the learning channel changes the task and that the performance on one learning channel is independent of performance on another learning channel. Similarly, Lindsley (1990) observed that teachers could not assume that fluency in one learning channel would be sufficient to assume that a student is fluent across all learning channels for a specific task. In the current thesis, learning channels will be used when discussing some of the procedures and results.

Other findings came from the results of classroom interventions developed by Precision Teachers. The data from thousands of classroom interventions were entered into a mainframe computer called the Behaviour Bank (Lindsley, 1990; 1991; 1992). The information included data on the type of skills measured, the frequencies reached, the settings where the projects took place, the procedures used, and any changes in performance (Koenig, 1971). The Behaviour Bank became a system that allowed teachers to share ideas and look for solutions to learning and behaviour problems. The basis for many applications of Precision Teaching came from the data collected in the Behaviour Bank. Unfortunately
this collection of data is difficult to source and most of the individual results and studies gathered are usually passed through the literature second-hand (Binder, 1996; Johnson & Layng, 1992; Potts, Eshleman & Cooper, 1993). One published evaluation, conducted in Great Falls in Montana over a 4 year time span during the 1970s, demonstrated that by adding 20 to 30 minutes of Precision Teaching per day to an otherwise regular curriculum (similar to most other schools in the district) the students improved between 19 and 40 percentile points on the Iowa Test of Basic Skills (Beck, 1979; Beck & Clement, 1991). More recent applications have combined Precision Teaching monitoring and fluency-based practice strategies with other effective methods (e.g. Direct Instruction) to form comprehensive packages that have enabled students to gain as much as 3 years of educational progress in 1 year of instruction (Binder, 1996; Johnson & Layng, 1992; 1994; Maloney, 1998; Kubina & Morrison, 2000). Despite these positive outcomes, behavioural fluency has received little attention from behaviour analysts working in the autism field (Weiss, 2001). The reason for this may lie in the fact that behavioural fluency, as a by product of Precision Teaching, was predominately developed away from the peer reviewed behaviour analysis journals. Without a supporting empirical data base many practitioners have been reluctant to adopt fluency-based procedures. Further still, the methods were also primarily devised in response to problems in regular or remedial education settings and many practitioners working with children with autism may not have had exposure to them. Lindsley (1991; 1992; 1996c) has summarised much of the inductive, unpublished findings gathered from applications of Precision Teaching and fluency-based instruction. One consistent finding was
that the frequency of skill could be directly targeted to build fluency. Johnson and Layng (1996) called this strategy frequency-building.

**Frequency-building: Procedures and findings**

The rationale for using the term **frequency-building**, as opposed to the commonly used fluency-building, is to emphasise that the procedures used in the current thesis are aimed specifically at increasing the frequency (or rate) of performance – and the outcome may, or may not, be fluent behaviour. The purpose of frequency-building procedures is to build skill performance by directly targeting the frequency of corrects, and decreasing the frequency of errors, to rates that predict fluency (Johnson & Layng, 1996). This practice has no doubt been influenced by the application of the standard celeration chart in Precision Teaching classrooms.

**Brief timings first**

In the early days of Precision Teaching, 1 to 2 minute timings were used for assessment purposes only (Howell & Lorson-Howell, 1990; Lindsley, 1991). However, it soon became apparent that brief timings could be used as practice sessions too (Miller & Heward, 1992). Evidence suggests that programming relatively long practice intervals during the early stages of frequency-building may suppress learning rates (Binder et al., 1990; Spence & Hively, 1993). In some cases the effects observed were the same as introducing a response-contingent, punishing stimulus - a steep drop off in the rate of responding.
However, Binder et al. (1990), Desjardins (1981), Haughton (1980) and Spence and Hively (1993) have all found that by practicing at much shorter intervals (between 10 and 30-s) correct response rates will often climb and many off-task behaviours will be eliminated. Haughton (1980) and Lindsley (1996c) called these short practice intervals sprints and found them to be one of the more effective and simple strategies for building skill frequency. This practice now continues throughout nearly all applications of Precision Teaching (Maloney, 1998) due to the simplicity and effectiveness of the procedure (Binder, 1985 cited in Binder, 1988). Although frequency-building is not the only way to develop fluency (Binder & Watkins, 1991; Binder, 1993; 1996; 2001; Johnson & Layng, 1996), frequency-building with frequency based aims and celeration targets is a method of instruction that has come to distinguish Precision Teaching/behavioural fluency.

The process of frequency-building is analogous to a runner training for a long distance race. First, he builds up his fitness (fluency) over shorter distances (intervals). Then, as fitness improves, the distance he has to run is gradually increased until the goal distance is completed within the desired time (performance aim). As he is building his fitness he may also regularly attempt the full distance to judge his progress toward the final goal. Desjardins (1981) adopted similar frequency-building strategies with her students. For example, writing the numbers 0 thru 9 may have a frequency aim set at 70 correct numerals, with 0 errors, complete within a 1-minute timing. A student who was practicing using 1-minute timings was unable to write above 35 correct letters per minute. The practice intervals were changed to 15 seconds and within 5 days
her rate climbed from 50 to 70 correct numbers written per minute. Because it was not sufficient to achieve fluent outcomes with this low rate, practice continued. The teacher tried a 1-minute timing and the student wrote 50 correct letters in that time. Next with 30-second intervals, her rate quickly accelerated from 60 to 80 per minute. The teacher tried another 1-minute timing and this time she wrote 73 numbers correctly – the aim was achieved. As can be seen from this example, frequency-building is dynamic, a check and balance between response rate and the length of the practice interval, and is an obvious extension of Precision Teaching. In a similar manner McDowell and Keenan (2001) employed a reversal design to measure the effects frequency-building had on the on-task behaviour of a 9 year-old boy diagnosed with attention deficit hyperactivity disorder. The data showed that during the early stages of frequency-building the learner's rate of responding decreased at each return to baseline phase. However, once a fluency-based frequency aim was achieved, his rate of responding endured during the final reversal phase. A similar experimental design will be employed in the current thesis.

Reinforcement strategies during frequency-building

Discussions about specific reinforcement strategies have been missing from descriptions of frequency-building procedures (Johnson & Layng, 1994; Lindsley, 1996c). What has been described, though, is the use of cheering and encouragement as a way to motivate behaviour whilst the learner responds (Binder, 1996, 2002; Johnson & Layng, 1992; 1994). Given that teaching programs for young children with autism often require the use of tangible, or
edible, reinforcers to be effective (e.g. Lovaas, Ackerman, Alexander, Firestone, Perkins, Young, Carr & Newsom, 1981) a description of how this cheering and encouragement can be replaced by other types of reinforcement to promote fluent responding is pertinent. It is anticipated that cheering and encouragement is contingent upon the teacher seeing the student performing accurately. Hence, a lot of immediate reinforcement delivered during an interval is likely to be based on the accuracy of a response rather than the passing of time or the strict adherence to reinforcing responses above a particular rate. Plus, the effect of sprints on target behaviour suggests variable-ratio schedules rather than interval or the differential reinforcement of high rate (DRHR) schedules. The evidence from thousands of standard celeration charts shows sprints resulting in rapid rate accelerations and, once at high levels, these rates persist in spite of environmental changes and endure over longer intervals of time (Lindsley, 1990; 1992). Behaviour maintained under a purely DRHR schedule is typically fragile and easily extinguished (Ferster & Perrott, 1968), and the high rates do not fit with descriptions of behaviour under fixed interval schedules. Many of the outcomes associated with frequency-building have also been demonstrated by human and nonhuman participants under fairly dense ratio schedules (Baron & Leinenweber, 1995; Killen & Hall, 2001; Stephens, Pear, Wray & Jackson, 1975; Stoddard, Sidman, & Brady, 1988; Weiner, 1969). For example, both Weiner (1969) and Raia, Shillingford, Miller and Baier (2000) showed that learners with a variable ratio history typically produce high and relatively constant rates of responding that is resistant to schedule changes, timing differences and other environmental alterations. By contrast, learners under schedules that produce
low rates of reinforcement (such as many interval-based schedules) tend to pause after reinforcement and respond at low rates.

Christopher Skinner and his colleagues (Belfiore, Lee, Vargas, & Skinner, 1997; Rhymer, Henington, Skinner & Looby, 1999; Skinner, 1998; Skinner, Belfiore, Mace, Williams-Wilson & Johns, 1997), plus the earlier work of Van Houten and his colleagues (Van Houten, Hill, & Parsons, 1975; Van Houten & Little, 1982; Van Houten, Morrison, Jarvis & McDonald, 1974; Van Houten & Thompson, 1976) have also shown the effect of combining response contingent reinforcement with brief timings during practice. The result was an increase in the rate and accuracy of a performance with improved generalisation and maintenance. The outcomes of fluency also parallel other basic and applied research in applied behaviour analysis. Killeen and Hall (2001) showed that enduring and resistant operant responses could be built through variable ratio schedules of reinforcement and with repeated performance. Similarly, Nevin, Tota, Torquato and Shull (1990) and Dube and McIlvane (2001) showed that resistance to change (i.e. stability and endurance) depended directly on the rate of reinforcement obtained whilst responding. Therefore, correlations obtained between high rate behaviour and fluency (Binder et al., 1990; Binder, 1996; Kubina & Morrison, 2001) may be a product of the highly frequent reinforcement received during practice.

The significance of this research is that it brings frequency building into the ambit of known reinforcement effects. It also allows for a finer design and description of the most effective reinforcement procedures used for frequency-
building that is needed for children who may not respond to verbal cheering and coaching and require tangible reinforcement (Lovaas et al., 1981; Harrington, 1996; Harris, 1996; Harris & Weiss, 1998; Sulzer-Azaroff & Mayer, 1991; Taylor & McDonough, 1996). Therefore, the frequency-building procedures used in the present research will generally increase the length of the timing intervals from 10 or 15 seconds to the desired 1-minute duration. Secondly, dense, variable ratio schedules of reinforcement will be used (e.g. VR4).

**Self-pacing**

Frequency-building strategies have employed methods that allow the learner to pace his or her rate of responding (Johnson & Layng, 1996). In essence, the learner can dictate the rate at which he or she performs. Jamming to music, reading a book, or writing a poem are all good examples of self-paced practice. All of these skills require complex response chains, which must be carried out in a particular sequence, but nonetheless have few imposed limits or ceilings and can be practiced at any rate (Johnson & Layng, 1996; Lindsley, 1996a). A key-defining feature of the frequency-building procedures used in the current thesis will be to allow self-pacing.

Self-pacing allows learners to respond as quickly as they can during practice, however differential reinforcement is needed to select and maintain the skills (or skill components) that are desired. From laboratory and applied results we know that fast responding is most likely when reinforcement is made contingent on responding (i.e. on a ratio schedule) with no attempt to limit the subject’s
responding (Ferster, 1953; Ferster & Skinner, 1957; Stoddard et al., 1988). Similarly, resistance to extinction is improved if the rate of reinforcement is high and on a variable-, rather than a fixed-, ratio (Ferster & Skinner, 1957; Stoddard et al., 1988). Therefore fairly dense, variable schedules of reinforcement will be used in the current thesis. To summarise, the procedural factors that appear to be important for increasing the frequency of a response under frequency-building conditions are:

1. Shorter 10-s intervals are an excellent procedure for establishing high response rates before longer intervals are tried (Binder, Haughton & Van Eyk, 1990).
2. Teach foundational, component skills first and then probe for applications to composite skills (Mayfield & Chase, 2002).
3. Practice components before practicing composites (Binder, 1996; Mayfield & Chase, 2002).
4. Reinforce speed plus accuracy not just accuracy (McDade, Austin & Olander, 1985). This is probably best achieved through a dense, variable ratio schedule of reinforcement and a task that allows the learner the freedom to respond at high rates to earn maximum reinforcement.
5. Give correction and performance feedback only after the timing interval is finished, and not during (Johnson & Layng, 1992, 1994).
6. Vary the order of the stimulus items for each interval (Johnson & Layng, 1996).
7. Practice strategies should be without limits and allow the learner to self-pace (Howell & Lorson-Howell, 1990).
8. Continue with frequency-building procedures until the learner can perform at a suspected fluency aim for at least 1-minute. Frequency aims achieved a shorter interval are rarely sufficient (Johnson & Layng, 1996).

Fluency: Described by the outcomes

Retention

In Precision Teaching a correct and error pair sampled from the same interval are called an accuracy pair (Eshlemann, 2001). For example, if a learner scores a rate of 100 correct and 5 errors per minute during a 60-s interval, this could be expressed as a 100(5) accuracy pair. (This is how correct-per-minute and error-per-minute pairs will be presented in the current thesis.) The term retention describes the stability of an accuracy pair after a period of time in which the individual has had no opportunity to perform the behaviour. This means that a learner can perform a skill long after the last time he or she performed it. An example would be singing the words to a song many years after you last sang it. Binder and Bloom (1989) and Binder and Sweeney (2002) have suggested that there might also be additional pay-offs associated with building skills to fluency. Both papers anecdotally suggested that achieving retention on one set of skills might be important for motivating people to work on subsequent training tasks. Furthermore, Binder and Sweeney (2002) suggested that continuous, self-managed measurement and charting might function to reinforce practice for some individuals.
To test for skill retention a teacher removes that skill from the learner’s practice exercises (a non-teaching break) after a frequency aim has been met. The teacher then measures the frequency of that skill at a later point in time. The time between frequency checks can be as short as a 1-day or as long as many months, however typically a break of 4 to 6 weeks is time enough to decide whether or not more practice is required (Johnson & Layng, 1992). As can be seen from this description, retention is very similar to maintenance. The difference being that when probing for maintenance, it is not important to restrict the learner from practicing the skill in other settings or situations. In fact, if the skill has been supported by naturally occurring contingencies outside of the training setting then maintenance has been achieved (Ivarie, 1986; Sulzer-Azaroff & Mayer, 1991). Retention, on the other hand, has only been achieved if the skill has not been performed between assessments and the learner performs the skill at the same frequency.

Poor skill retention is a significant problem for young children with autism. The results from intensive, long-term behavioural interventions show that skill retention tends to be positively correlated with the number of teaching hours the child receives each week (Birnbrauer & Leach, 1993; Fenske, Zalenski, Krantz, & McClannahan, 1985, Lovaas, 1987; McEachin, Smith, & Lovaas, 1993, Sheinkopf & Siegel, 1998). The evidence from these studies showed that children who received at least 28 hours of intensive therapy per week showed better retention than children who received fewer hours. However, children who also received continuous treatment services for at least 2 years fared even better. They demonstrated better retention and generalisation and achieved greater gains
on measures of adaptive behaviour. Therefore, it would be beneficial if skills taught to young children with autism responded to frequency-building procedures by demonstrating improved retention.

Although retention has been achieved using various practice strategies, such as overlearning (Baldwin & Ford, 1988; Hagman & Rose, 1983; Kruger, 1929), massed practice and spaced practice (Anderson, 1985; Johnson & Layng, 1996), immediate retelling (Brown, Dunne & Cooper, 1996) and with carefully designed curricula, such as Direct Instruction (Becker, 1977), the following research review will focus mainly on studies that show retention effects following frequency-building. A lot of the evidence to support the claim that Precision Teaching improves “retention” has been acquired through inductive, chart sharing and clinical case studies rather than controlled experimental research (Binder, 1996; Eshlemann, 2000, 2001). However, chart shares and data collected in the “Behavior Bank” (Koenig, 1971) do suggest that increasing the frequency of a skill, beyond 100% accuracy, improves retention (Binder, 1996; Lindsley, 1991). A recent study by Bucklin, Dickinson and Brethower (2000) taught a group of adults some basic skill components (nonsense symbols, Hebrew letters, and Arabic numerals) to 100% accuracy. Half of the group then received frequency-building on those same items until they reached a frequency aim of 70 correct per minute. Immediately following training the frequency-building group demonstrated better application to a composite skill. The frequency-building group also demonstrated far superior retention at a 4 and 16-week follow-up.
An earlier study by Ollander, Collins, McArthur, Watts, and McDade (1986) compared the performance of a group of nursing students taught using traditional lecture methods to another group taught using fluency-based methods (flashcards, charting, and frequency based aims). The fluency-based groups performed better on tests immediately following training and again at an 8-month follow up retention probe. However, like the Bucklin et al. (2000) study, the two groups differed in the amount of practice given. So it cannot be said that frequency-building was the critical variable.

Berquam (1981) provided better control by counterbalancing for practice effects. Berquam’s data from that study showed that those third grade children who completed frequency-building exercises showed better retention at a 10-day follow up assessment. Unfortunately, no further follow-up assessments were taken so it was unknown if this superiority continued beyond this point. Similarly, Ivarie (1986) showed that frequency-building strategies promoted better retention for some of their fourth grade subjects – primarily those students who were performing at below average levels in the classroom. However, most subjects benefited just as well from accuracy training alone. Shirley and Pennypacker (1994) also showed that frequency-building resulted in better retention than practicing without a rate criterion. However, when compared to an accuracy training condition (that featured some overlearning), only one of the three children demonstrated better retention for having completed frequency-building practice. Most recently Gaunt (2001) suggested that frequency alone might not be a sufficient indicator for predicting skill retention.
There have been other claims that frequency-building is superior to practice alone, a lack of controlled comparisons makes it impossible to empirically support that claim. For one, Orgel (1984 cited in Binder, 1996) used flash cards to achieve a frequency aim of 50+ flashcards per minute with half of the students in a university calculus class. 6 weeks later a retention test was given and those students who reached the frequency aim performed nearly twice as accurately as those students who did not reach the frequency aim. Also, Ritesman, Malanga, Seevers and Cooper (1996) showed that retention was positively related to frequency-building practice when teaching developmentally delayed students to retell information from a current affairs broadcast. However, retention was also further improved by using prompts and immediate practice (rather than delayed practice) during acquisition. Therefore, without a comparison to a non-frequency-building procedure their results cannot support frequency-building’s superiority for improving retention. Similarly, data collected by McDade (1998) showed good retention following frequency-building however, like most other studies, a lack of good experimental control which make it difficult to rule out that practice alone might have resulted in similar outcomes.

This conclusion is acknowledged in reviews of the fluency literature (Binder, 1996; Eshlemann, 2001; Kubina & Morrison, 2000). In fact many studies of overlearning and mastery learning show similar outcomes (Baldwin & Ford, 1988; Hagman & Rose, 1983; Skinner, 1998). At this point in time more data are needed.
Endurance and stability

The term endurance has come to refer to two behavioural outcomes (Binder, 1996). Firstly, endurance can refer to the firmness of an accuracy pair over longer periods of time. For example, during 1-minute practice sessions a young reader regularly reads around 200 words in context. To test for endurance, a timing interval of 10 minutes is tried. At the end of the timing period the number of words she has read aloud are counted up. She has read 2080 words – just over 200 words per minute. In this example the learner has just demonstrated skill endurance over a 10-minute period. As can be seen from this example “…the learner can perform the skill at the same frequency for periods of time that are longer than the timing period used during practice…” (Johnson & Layng, 1996 p.285).

The second type of endurance has also been called “stability” (Johnson & Layng, 1996). Stability is demonstrated when the frequency and ratio of an accuracy pair remains firm despite a change in the environment. In a classroom setting, this “change” might refer to the learner hearing other children talking, seeing other children playing outside, hearing the playing of music nearby, or being instructed in a new classroom.

Currently, there are only a few studies that directly compare the stability of a highly accurate, high rate performance to a lower rate, inaccurate performance. A pilot study conducted by Binder in 1979 (cited in Binder, 1996) showed how the frequency of a skill could be affected by the presence of distracting stimuli.
adult participants performed 5 see-say tasks for 3 minutes each. Cumulative records taken from each 3-minute interval revealed that both participants performed more rapidly on those tasks that they were familiar with. Both participants then repeated the same tasks, but this time an audio stimulus was played to them for 30-s of each 3-minute interval. The results showed that whenever this signal was introduced the performance rate for unfamiliar skills dropped off considerably, whereas the rate of familiar tasks remained relatively unchanged.

A lot of the published research on endurance in the Precision Teaching/fluency area comes from the work of Binder and his colleagues (Binder, 1993; 1996; Binder & Bloom, 1989; Binder, Haughton & Van Eyk, 1990; Binder & Sweeney, 2002). Another pilot study conducted by Binder in 1984 (cited in Binder, 1996) demonstrated how the endurance of a skill could be tested by time manipulations. In this study 75 participants were required to write the digits 0 to 9, over a 15-second, 30-second, 1-minute, 2-minute, 4-minute, 8-minute, and a 16-minute interval. The performance rates obtained from the 15-s interval varied from about 20 per minute up to around 150 per minute. As each progressively longer interval was tried, those participants who performed at less than 70 per minute could not sustain their performance rates. In fact, the slower the rate achieved under the 15-s intervals, the sooner the participants rates diminished under increasingly longer intervals. In other words, they failed to show endurance. Participants who performed at over 70 per minute, however, maintained a fairly consistent rate across all of the intervals.
Binder et al. (1990) and Binder (1982 cited in Binder, 1996) also demonstrated that practice any longer than 1 to 2 minutes resulted in non-compliance for some learner’s. Binder et al. (1990) suggested that a lack of endurance (as demonstrated by a drop off in performance rate with increasing intervals) offers an alternative, constructive way of understanding “attention” problems. Given that “attention” problems are common when teaching young children with autism (Maurice, 1993; Lovaas et al., 1981) these findings certainly bear relationship to the participants in the current thesis.

**Application and Adduction**

Johnson and Layng (1994) suggested that there were at least three types of skill application that are positively influenced by the frequency at which the component skills are performed (Binder, 1993, 1996; Binder & Bloom, 1989; Bucklin et al., 2000; Haughton, 1972, 1980; Johnson & Layng, 1992; 1994; Oddsson, 1998). The first, and perhaps the simplest to test, was the direct transfer of training from one setting to the next such as transferring phonics decoding from instructional materials to words in newspapers and books. The second involved chaining components that have been taught in isolation. For example, a child can trace the outlines of shapes fluently, plus she can also colour in line drawings very accurately and rapidly. When given a picture of a car, she copies the outline from the picture and then colours in her drawing whilst staying within the lines. This kind of application is related to other areas of applied behaviour
analysis such as task analysis and forward and backward chaining. The third type involves a non-linear recombination of skills, sequences, and repertoires from possibly unrelated subject areas. This kind of application generally results in creative skills, such as debating or writing a thesis. The following review will be restricted to examining the evidence of skill application following fluency-based instruction and the influence frequency-building simple, components skills has on composite repertoires. Apart from fluency-building strategies, other tactics for generalisation were reviewed earlier.

The initial occurrence of some applications has been attributed to a process called contingency adduction. Contingency adduction occurs when multiple repertoires or components combine with little, if any, instruction (Andronis, Goldiamond & Layng, 1983; Johnson & Layng, 1996; Binder, 1996). Johnson & Layng (1994) described how fraction word problems were consistently a problem for their students, some scoring as low as 3 correct in a minute (with up to 11 errors). Probes of the component skills revealed that none of these students were fluent with simple addition math facts. An instruction sequence was put into place that taught addition math facts to rates that predicted fluency (component). Following this, and with no extra instruction, a probe of fraction word problems revealed that all learners had jumped to 13 to 14 corrects per minute (composite). This example is consistent with most reports of adductions, with the common feature being that they often occur without any formal instruction (Binder, 1996). The procedures used in this thesis will try to replicate these findings, by removing any teaching procedures or programmed reinforcement contingencies from the application probes.
Andronis et al. (1983) described the adduction process as an instant that can only happen once (any occurrences thereafter are applications) when behaviour patterns or repertoires are provoked by contingencies that are different than those that supported the original behaviour pattern or repertoire. The effect of contingency adduction is generative in nature. This means that fluent components can recombine with any number of other components to create exponential jumps in performance. This will generally occur when the environment selects it, given the right contingencies and conditions (Binder, 1996; 2002). Binder (1996) claimed that of all the outcomes associated with fluency the greatest amount of evidence exists for applications and adductions following fluency. Unfortunately none of this evidence has been published for scientific peer review.

Johnson and Layng (1996) have theorised that the reason fluency based, frequency-building procedures promote adduction and generativity is because these procedures use massed practice and paced repetition. They suggested that practice increases the probability that a behaviour will be performed again, given the right environment. From this selectionist point of view, they suggested that fluent behaviour was more likely to be selected by the current supporting contingencies than nonfluent behaviour.

Binder (1996) and Haughton (1972), amongst others, have suggested that for applications to occur minimum component behaviour frequencies were necessary. Even in the presence of otherwise ideal reinforcement and
contingency arrangements, slow and inaccurate component skills often impeded progress (Haughton, 1972). From recent descriptions (Bucklin et al., 2000; Kubina & Morrison, 2000) application has been often viewed as a “bonus” to achieving high, accurate frequencies of performance. Plus, how far application spreads to other tasks also appears to vary significantly from learner to learner (Lindley, 1991; 1992). Skill application may also be influenced by many factors other than practice. For example temporal factors such as behavioural momentum (Mace, Mauro, Boyajian & Eckert, 1997), the Premack principle (Premack, 1959; Homme, deBaca, Devine, Steinhorst, & Rickert, 1963), differences in effort (Friman & Poling, 1996), and schedules of reinforcement (Lattal & Neef, 1996) may also help to describe why and how applications occur but are beyond the scope of this thesis.

Binder (2002) has already begun to unravel some of these variables, often exploring research conducted outside of behaviour analysis for solutions. He has cited ergonomic modification, information analysis, and effective time management as some of the critical components towards promoting the application of skills for many of his learners. Similarly, Johnson and Layng (1996) mentioned the big influence effective instructional design (Adams & Englemann, 1996; Englemann & Carnine, 1982; Tieman & Markle, 1990) has had on promoting application and adductions. In following these steps, research may uncover the “why?” and “how?” of application. By understanding the “why?” a “technology of application” may be created. The potential for this technology is for even greater gains, with even more hours of instruction time saved.
The importance of demonstrating behavioural fluency away from centre-based applications

Learners in centre-based programs gain repeated exposure to the way information is presented and practiced (e.g. Johnson & Layng, 1992; Vargas & Vargas, 1991). For example, once a learner has practiced frequency-building a few times she will often demonstrate skills “going as fast and as accurately as you can”, “don’t worry too much about errors”, “how to read stimulus sets”, and will chart and even analyse her own data (Binder & Sweeney, 2002; Cole & Chan, 1990; Johnson & Layng, 1992; 1994; Lindsley, 1990; 1992; Vargas & Vargas, 1991). When using fluency-based training with sales employees, Binder and Sweeney (2002), Binder and Bloom (1989), and Bonser and Gerzina (2001) all noticed that initially a lot of shaping and prompting are needed to help trainees to learn the skills they need to practice to fluency. However, with repeated practice, trainees gain the skills mentioned above and future practice can be completed independently - often only needing the trainer to give them their practice materials or to provide quick checks that they are performing correctly. Most instructional procedures are rarely unique to one skill, and teachers will use the same general teaching methods to present any number of tasks. In fact, Direct Instruction procedures have been designed to make teaching more efficient and effective by maintaining a standard way of presenting, practicing, and reviewing information across their entire curriculum.
(Adams & Englemann, 1996; Binder & Watkins, 1990; Englemann, 1992; Englemann & Carnine, 1981; Silbert, Carnine & Stein, 1981). Similarly, research conducted with younger populations or people with developmental disabilities, has demonstrated or described that compliance to instruction is a skill that, when learned successfully, significantly improves the outcomes of instruction (Haughton, 1980; Harlow, 1949; Englemann and Colvin, 1983; Lovaas et al., 1981; Maurice, 1993; Romanczyk, 1996). Kohler (1925) showed that apes also showed better learning when taught with familiar procedures than with novel ones. Englemann and Carnine (1982) suggested that this is learning to learn, and is the “…quintessence of generalisation…” (p.373). Therefore, it would be expected that children with experience in a centre-based fluency program would perform differently than a child without any previous experience. Given that the main purpose of this thesis is to determine if frequency-building procedures will promote skill generalisation, these potential sources for skill generalisation need to be controlled. The current thesis presents an opportunity to evaluate frequency-building strategies when teaching naïve learners. In fact, many were so naïve that many had never performed these skills before, and all had no previous experience with frequency-building procedures.

Rationale and Aims

The main purpose for this study is to determine if frequency-building procedures are a viable solution to the problem of skill generalisation for young children
with autism. This purpose will be achieved by determining if imitation, tracing, writing, simple addition, and phoneme reading skills taught to young children with autism, with no previous experience with frequency-building procedures, will demonstrate RESAA outcomes and respond to frequency-building procedures in ways that are consistent with non-autistic populations.

Furthermore, the experiment addresses 6 further aims. These are:

1. To determine if combining discrete trial training with frequency-building strategies will result in far greater gains on measures of generalisation than when using discrete trial training alone.

2. To compare and contrast discrete trial training with frequency-building to determine which approach is more effective on measures of retention, generalisation/application, and the preference ratings of participants when matched for reinforcement and practice.

3. To determine if the rate of target skills practiced under frequency-building conditions positively predicts the quality and quantity of applications, adductions, and skill generalisation.

4. To compare and contrast the effects of using many exemplars with few during frequency-building practice, which approach is more effective based on measures of retention, endurance, and generalisation/application?

5. To determine if controlled-operant tasks, such as gross motor imitation, can be modified and practiced to rates high enough to achieve RESAA outcomes.
6. To determine if the results suggest that the frequency-aims gathered from studies of nonautistic populations may be used to set frequency-aims for young children with autism.
EXPERIMENT 1: AN EVALUATION OF THE EFFECTIVENESS OF
COMBINING FREQUENCY-BUILDING WITH DISCRETE TRIAL
TRAINING TO ACHIEVE GENERALISED IMITATION FOR YOUNG
CHILDREN WITH AUTISM

Introduction

Children learn important social, cultural, and adaptive behaviour by imitating the
behaviour of others and through the contingent social reinforcement of their
actions (Peterson, 1989). However, for the young child with autism imitation
rarely comes naturally (Rogers, 1999). The absence of imitation is often noticed
by caregivers during infancy and has been identified as a primary deficit of
autism (Jones & Prior, 1985; Lovaas et al., 1981; Rogers, 1999). Poor imitation
also typifies the social impairment and lack of reciprocity that defines the
disorder (American Psychiatric Association, 1994). Therefore, it is not
surprising to discover that most early intervention programs devote a significant
amount of teaching time to teaching generalised imitation (Harrington, 1996;
Harris, 1996; Harris & Weiss, 1998; Lovaas et al., 1981; Maurice, 1993; Taylor
& McDonough, 1996; Rogers, 1999). The consequences for developing good
imitation skills are particularly valuable because these form the foundation for
future learning (Harris & Weiss, 1998; Lovaas et al., 1981; Rogers, 1999; Taylor
& McDonough, 1996). For the child with autism imitation may be one of the
most important skills to master. Rosales-Ruiz and Baer (1997) suggested
achieving generalised imitation is almost always a behavioural cusp in the learning history of the young autistic child, because it results in an “…expansion of the child’s repertoire [that] can suddenly and systematically be as explosive as the social environment cares to make it, simply by modelling new skills…” (p.535).

The research clearly shows that generalised imitation skills have been associated with greater gains across a wide variety of skills and measures. For one, the collective results from a number of early intervention programs show that children with highly accurate, generalised imitation skills achieved larger gains on measures of adaptive behaviour than similar aged peers with poor imitation skills (Dawson & Osterling, 1997). Highly accurate generalised imitation skills also predicted larger gains on measures of expressive language whether taught directly, via a structured program (Kent, 1974), or if taught through indirect, incidental teaching strategies (Stone, Ousley & Littleford, 1997). Accurately imitating the actions of peers in play settings has also been associated with the development of appropriate play skills (Haring & Lovinger, 1989; Jones & Prior, 1985) and good motor imitation skills have been associated with better performance on measures of instructional compliance and academic engagement (Englemann & Colvin, 1983; Jenson, Reavis, Clark, & Kehle, 1986). All of these gains were observed in children who were taught imitation skills to accurate levels. However, if the extra benefits of improved adductions and applications gained by training to fluency generalise to imitation skills for children with autism, then there is a potential for even larger gains.
Generalised Imitation

Garcia, Baer and Firestone (1971) were one of the first to identify the nature of generalised imitation following training to a 100% accuracy criterion. They observed that generalised responding was promoted across settings, over time, and to other movements. However, generalisation was restricted to topographically similar forms. Young, Krantz, McClannahan, and Poulson (1994) also observed that accurate imitation skills only generalised to topographically similar movements. Dawson and Osterling (1997) reviewed the outcomes of skills taught using discrete trial training procedures as part of comprehensive early intervention programs. Their summary showed that the generalisation of highly accurate trained responses was most commonly achieved across trainers and across familiar settings. Furthermore, they too observed that motor responses were often restricted to topographically similar skills. However, Koegel and Rincover (1977) showed that accurate gross motor imitation skills failed to generalise to nonreinforced trainers and new settings. Based on this evidence it is expected that if generalised imitation occurs following discrete trial training it will be limited to topographically similar responses.

In the fluency and automaticity literature motor imitation skills have not been tested. However, there have been a few examples of teaching motor skills to fluency with normal adult populations. The results have shown that participants who practiced motor skills to fluency (speed plus accuracy) showed better retention 1 week after training than a group who were given the same amount of practice, but to an accuracy criterion alone (Naslund, 1987) and overtraining the
components of motor tasks was positively related to the improved accuracy of composite task performance (Gagne & Foster, 1949). These two studies illustrate that overtraining and frequency-building motor skills resulted in outcomes consistent with the behavioural fluency predictions (Binder, 1996; Johnson & Layng, 1992; 1994; Lindsley, 1992; Maloney, 1998). However, the evidence is sparse and fails to provide any clues to help predict if, or how, frequency-building practice will benefit the gross motor imitation skills of young children with autism.

Exemplar Sets

Stokes and Baer (1977) recommended programming many stimulus and response exemplars during training to promote generalisation. White et al. (1988) later quantified this recommendation by suggesting that at least 6 exemplars should be used during training. A search of the PsychLit database revealed that the effect of varying the number of exemplars during imitation training has yet to be tested. Similarly, there were no data based examples in the fluency literature either; although current practice is to use more exemplars rather than fewer for most skills (Binder, 1996; Johnson & Layng, 1992; 1994). Nonetheless, an experimental analysis may reveal that current practice and best practice differ.

The current experiment has four main aims. The first one is to determine if imitation skills taught to children with autism respond to frequency-building
procedures in ways that are consistent with previous successful applications of fluency-based training. Secondly, the experiment aims to determine if gross motor imitation, an inherently controlled-operant task, can be modified and practiced to rates high enough to achieve RESAA criteria. Thirdly, the current experiment aims to determine if combining discrete trial training with frequency-building practice will result in greater gains than discrete trial training alone on measures of generalised imitation. These measures include topographically similar and topographically dissimilar movements. It is expected that following discrete trial training that generalisation will be limited to movements topographically similar to the training movements. Without the benefit of previously published evidence with similar skills and participants it is uncertain what the effects of the frequency-building conditions will be.

The final aim is to determine if young children with autism can achieve fluency on gross motor imitation skills using frequency-building procedures when practicing with only 3 exemplars. This number was chosen because it was less than the minimum number of 6 as recommended by White et al. (1988). The rate and accuracy of the target behaviour and measures of generalised imitation will determine if RESAA outcomes have been achieved. The purpose is to provide data of a skill taught with few exemplars as a contrast to data of the same skill taught with multiple exemplars. Although direct comparisons between the children are limited due to the single-subject designs presented here, any large differences may prove valuable as an impetus for further inquiry.
On a procedural note, it would seem impossible to keep the procedures free during imitation training when the trainer's movements are the discriminative stimuli. However, near free-responding can still be achieved if the trainer adopts a less dominant role during each frequency-building interval. To retain an element of free-responding the trainer will: (1) respond to the student’s movements by modelling the next movement as soon as the student completes his attempt; and (2) deliver corrective feedback only after the timing interval is finished. These two simple modifications will be a part of the frequency-building procedures used in this experiment as an attempt to keep responding as free as possible and improve the validity of response rate as a measure of the student’s performance.

Method

Selection Criteria and Participants

Seven children were assessed for this experiment and had all been independently diagnosed with Autism 299.00 (APA, 1994). The names used here are not the children’s real names. Each child’s parents had given written informed consent for their child to participate in this experiment. An agreement was also made with the parents of the children, and the behaviour therapists working with the
children, that any of the skills being taught as a part of this experiment would not be taught in the home programs for the duration of the experiment.

As part of the selection procedures, the children were introduced to a token exchange system (gradually faded in) and then tried for 1 week in their home programmes. The final version of this trial system resulted in a token being delivered as a consequence for every third correct response (a FR3 schedule). When a child had earned 15 tokens he was given either music, Nintendo® Game Boy video games to play with, stamps, stickers, spinning tops, sparkler toys, tickles, or edibles (M&M’s®, potato chips, cheese twists, chocolate, cool drink and lolly pops). If this system reinforced the child’s behaviour (the number of correct responses per session increased), then the child was included in the experiment. Of the initial 7 children tried, 4 passed this criterion and participated in the current experiment.

Adrian

Adrian was 2 years and 7 months of age at the commencement of experiment 1 and had recently been diagnosed with autism. During his assessment he gave fleeting eye contact when prompted and he did not imitate any motor movements or sounds. He also lacked interpersonal and social communication skills and displayed some bizarre vocalisations. These observations were consistent with reports of his behaviour at home. Following his assessment and leading up to
this experiment Adrian had received 8 weeks of applied behaviour analysis
discrete trial intervention at approximately 6 hours per week. In that time he had
learned to sit on a chair for 2 minutes at a time, hand objects over to the trainer
when asked (prompted by the trainer holding out his hand), look at the trainer
when asked (prompted by the trainer saying "Look at me."), and imitate a few
sounds ("mmm", "aaa", and "sss"). His verbal imitation, however, was limited
to one or two sounds at any one time, and then the interaction would end. These
skills were yet to generalise reliably outside of the training setting. Within his
therapy sessions edibles (usually potato chips) and lots of praise were given as a
consequence for every correct response.

Simon

Simon was 4 years and 6 months of age at the commencement of the study.
Independent psychological reports suggested that he had been a difficult child to
assess and he that he completed few of the assessment-related tasks. At home he
rarely followed verbal prompts and only occasionally tried to communicate
verbally - and when he did his speech intelligibility was poor. Simon had been
receiving ABA intervention for 10 weeks, at 4 hours per week, prior to
participating in this experiment and the data taken from these sessions showed
that his progress had been inconsistent. When presented with task demands
Simon often exhibited "avoidance" behaviour, such as rocking back and out of
his chair, throwing himself on the floor, throwing items, and aggression. He had
started to learn some basic attending skills and was capable of some gross motor imitation within a structured teaching session, but generally he did not. There weren’t any recorded applications to situations outside of the training sessions. During his sessions food paired with praise had been given as a consequence for a correct response.

Michael

Michael was a 5-year old boy with autism. On an assessment using Leiter International Performance Scale (Roid & Miller, 1997) he passed all the items up to the 6-year level, which placed him in the “superior” range on that test. However, Michael was also just as likely to ignore requests and become aggressive if prompted, which was reflected in some earlier assessment where he failed to complete any of the items presented to him. Michael had been receiving home-based ABA intervention off-and-on for nearly 18 months. Data taken from these sessions indicated that his progress had been inconsistent and he was yet to master any of the skills reliably (no more than 2 sessions in a row and he rarely displayed these skills outside of the training sessions). Comments from his teachers suggested that he was mostly noncompliant within the sessions and that this had impeded his progress. The data from his sessions showed that he imitated only occasionally and would often fail to complete more than 3 or 4 motor imitations in a row before throwing a tantrum. During these sessions edibles, toys, and praise had been given as consequences for a correct response.
Adam was a 6 year old boy who and had been diagnosed with autism when he was 3 years old. A recent independent psychometric assessment (WPPSI-R [Wechsler, 1989]) placed him in the “borderline” range. He had received approximately 12 months of home based ABA intervention, however the consistency of this programme varied from 2 to 10 hours per week. Observation records taken from these sessions suggested that he was aggressive at times and he would regularly tantrum in response to task demands – particularly if the task was a novel one. He had imitated some gross motor movements in his training sessions however this was limited to single movements (e.g. put arms up in the air). The data taken from his last few sessions showed that he had only achieved 4 or 5 gross motor imitations out of 20. He had showed some generalised imitation to situations outside of the training sessions however this was limited to 2 or 3 instances per week. His fine motor skills were clumsy and he had problems manipulating small objects with his fingers. In his home program toys, tickles, music, play activities, food and praise had all been given as consequences to desired behaviour.
Setting

The author was the trainer for all of the experiments and since 1992 had taught young children with autism using applied behaviour analysis procedures. He had also completed the course work and practical placements for the Master of Applied Psychology programme.

All procedures were conducted at the home of each child, in a medium sized room (approximately 3 metres by 4 metres by 2.5 metres). Each room was well lit, ventilated, and contained child-sized chairs. A “Sony® Video 8 Handy Cam” (CCD-TR670E) video camera mounted on a tripod, positioned behind the trainer and facing the child, was placed in the corner of the room to record each session. To keep time during the sessions the trainer wore a digital timer around his neck that beeped when the timer had counted down. The sound from the timer was loud enough to be audible to the trainer, to the child, and could be heard clearly on the soundtrack of the videotape. Pencils and sheets of A4 paper were supplied when needed for one of the application sets (simple drawing). The trainer also wore a golf-stroke counter on his wrist, to aid him in counting the target behaviour. Plastic tokens and reward items were placed on a tray behind the trainer. This reward tray included a compact disc or tape to listen to, Nintendo® Game Boy video games, stamps, stickers, spinning tops, sparkler toys, board games, and edibles (M&M’s®, potato chips, cheese twists, chocolate, cool drink and lolly pops).
Response Definitions and Target Behaviour

The two terms used to describe and define the teaching procedures are interval and session. An interval describes a length of time, measured in seconds, during which teaching occurs and the target behaviour is measured. The start and end of an interval was signalled audibly by the beep of the timer. A session describes the number of intervals that occurred on a single day. For example, in a single frequency-building session Michael was given ten, 10-s intervals of gross motor imitation training. Within any given session the interval length was always the same.

The target behaviour for Adrian and Simon was imitating the trainer doing each of the 10 motor movements listed in Table 1.1. For Michael and Adam, the target behaviour was imitating clapping hands, placing arms up in the air, and tapping legs. The motor movements used in the application probes to assess for generalised imitation are presented in Table 1.2. Adrian and Simon were presented with all of the sets listed whereas Michael and Adam were only assessed on 4 of these sets (gross motor imitation, gross motor imitation whilst standing, 2 step gross motor imitation, and 3 step gross motor imitation). An imitation was scored correct if the child’s motor movement matched the trainer’s movement, it occurred within 5-s of the trainer modelling it, and the movement finished before the end of the interval. Anything else was scored as an error. The order in which the trainer modelled these motor movements varied within, and across, teaching days.
Data Collection and Interobserver Agreement

Three dependent measures were used in this experiment. The first two measures were the number corrects and the number of errors made per interval when imitating the trainer’s motor movements. The interval with the most number of corrects per minute for that session was recorded on the standard celeration charts. If more than one interval met this criterion then, of those intervals with the most number of corrects, the interval with the highest number of errors was charted. This method of selecting the most corrects and most errors as the best performance for that session is part of standard Precision Teaching practice and is adhered to here for consistency with existing practices. Corrects and errors were then expressed as count per minute scores. For example, if Michael imitated 10 movements correctly and made 3 errors during a 10-s interval his score would be 60 correct and 18 errors per minute. For brevity, this result will be expressed as an accuracy pair, 60(18), when discussed in the text.

The third measure was the percentage of correct responses during application probes. For these assessments the interval with the highest percentage correct score was charted. Interobserver agreement was accomplished using the video footage of the sessions. Two trained observers scored the session independently of each other and then compared the scores they had obtained for agreement. The goal was for both scorers to agree upon (a) which interval met the criterion as being the best, and (b) that they had both scored the same number of corrects and errors within that interval. If the observers disagreed then counting was
repeated until they agreed. The percentages of agreement checks completed across the 4 children over the phases of the experiment are presented in Table 1.3.
Table 1.1

The 10 Gross Motor Movements Assessed at Baseline, Taught to Accuracy and Trained in the Frequency-building Sessions in Experiment 1

<table>
<thead>
<tr>
<th>Sets</th>
<th>N</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Motor</td>
<td>10</td>
<td>Clap hands, place arms up, tap table, wave, stomp feet, tap legs, shake head, nod head, turn around, cover face with hands.</td>
</tr>
</tbody>
</table>
Table 1.2

Motor Movements From the Imitation Sets Used For The Application Probes in Experiment 1

<table>
<thead>
<tr>
<th>Sets</th>
<th>N</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Motor Actions w/ Objects</td>
<td>10</td>
<td>Tap shoulders, jump (lift legs up and down), circle arms, tap stomach, &quot;march&quot; (whilst seated), put arms out, knock on wall/door, put hands on waist, rub hands together, tap head.</td>
</tr>
<tr>
<td>Actions w/ Objects</td>
<td>10</td>
<td>Place block in bucket, ring bell, push toy car, wave flag, hit drum, put on a hat, brush hair, drink from a cup, place coin in a cup, stamp paper.</td>
</tr>
<tr>
<td>Fine Motor Movement</td>
<td>12</td>
<td>Clasp hands together, open and close hands, tap index fingers, tap thumbs, wiggle fingers, fold fingers together, tap index finger to thumb, point index finger to palm, extend index finger, place thumbs up, make a peace</td>
</tr>
<tr>
<td>Sets</td>
<td>N</td>
<td>Items</td>
</tr>
<tr>
<td>----------------------</td>
<td>----</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Oral Motor Movement</td>
<td>9</td>
<td>Open mouth, stick out tongue, put lips together, tap teeth together, blow, smile, pucker, place tongue to top of teeth, place top teeth over lower lip.</td>
</tr>
<tr>
<td>Gross Motor w/Standing</td>
<td>20</td>
<td>Jump up and down, turn around, put arms out, march, sit on the floor, bang hands on the floor, knock on door, crawl, walk around the chair, lay down on the floor, put hands on hips, twist at waist, touch toes, hop lift one foot up, fly like a plane, lift up chair, kick a ball, tap table, put hands on waist.</td>
</tr>
<tr>
<td>Block Patterns</td>
<td>5</td>
<td>Single-block placement, two-block construction, three-block construction, four-block construction, five-block construction.</td>
</tr>
<tr>
<td>Simple Drawing</td>
<td>5</td>
<td>Vertical line, horizontal line, plus sign, circle, diagonal line.</td>
</tr>
<tr>
<td>Sets</td>
<td>N</td>
<td>Items</td>
</tr>
<tr>
<td>-------------------</td>
<td>----</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Gross Motor (2 step)</td>
<td>10</td>
<td>Tap table-clap hands, wave-place arms up, stomp feet-tap legs, tap shoulders-circle arms, tap stomach-put arms out, put arms out-tap table, tap table-wave, wave-stomp feet, stomp feet-tap shoulders, tap shoulders-clap hands.</td>
</tr>
<tr>
<td>Gross Motor (3 step)</td>
<td>5</td>
<td>Tap table-clap hands-wave, wave-place arms up-stomp feet, stomp feet-tap legs-tap shoulders, tap shoulders-circle arms-tap stomach, tap stomach-put hands on waist-put arms out.</td>
</tr>
<tr>
<td>Fine Motor (2 step)</td>
<td>6</td>
<td>Clasp hands together-open and close hands, tap index fingers-tap thumbs, wiggle fingers-rub hands together, tap index finger to thumb-point index finger to palm, place thumbs up-make a peace sign, tap index fingers-wiggle fingers.</td>
</tr>
<tr>
<td>Sets</td>
<td>N</td>
<td>Items</td>
</tr>
<tr>
<td>-------------------------</td>
<td>---</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Fine Motor (3 step)</td>
<td>4</td>
<td>Clasp hands together-open/close hands-tap index, tap index fingers-tap thumbs-wiggle fingers, wiggle fingers-rub hands together-tap index finger to thumb, tap index finger to thumb-point index finger to palm-place</td>
</tr>
</tbody>
</table>
Experimental Design

Experiment 1 took place over 18 months and consisted of two separate designs. The first design was used with Adrian and Simon. Adrian and Simon were assessed using an ABACA design with long-term follow up. Concurrent periodic probes were taken to assess for any generalised imitation (application probe) across other movements. Before commencing the experiment an adult was tried a few times and he imitated the 10 motor movements at a rate between 60 and 70 correct movements per minute. Therefore, a rate between 60 and 70 per minute was used as the frequency aim for both Adrian and Simon. Tests for application were administered whenever there was a phase change (e.g. a return to baseline phase, at follow-up etc) or if the frequency aim was reached. During frequency-building the interval times were systematically increased, based on the child’s progress, from 10-s to 20-s, to 40-s, and then to 60-s. The design is illustrated graphically in the following flow chart. On the flow chart the grey bars represent the introduction of non-teaching breaks. These breaks were used to test for retention.
Table 1.3

The Percentage of Data Checked for Reliability in Experiment 1

<table>
<thead>
<tr>
<th>Phase</th>
<th>Child</th>
<th>Baseline</th>
<th>Frequency-building</th>
<th>Application Probes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adrian</td>
<td>65%</td>
<td>66%</td>
<td></td>
<td>60%</td>
</tr>
<tr>
<td>Simon</td>
<td>59%</td>
<td>66%</td>
<td></td>
<td>62%</td>
</tr>
<tr>
<td>Michael</td>
<td>60%</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Adam</td>
<td>41%</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>
In the second design, Michael and Adam practiced with only 3 exemplars.

Frequency-building intervals began at 10-s intervals and continued until they reached a frequency aim of 60 per minute. They then each spent about 6 sessions practicing under 20-s, and then 30-s intervals, before finally being tried under 60-s intervals. An application probe was run once about every 14 calendar days.

An application-based fluency criterion was also set based on the results achieved with Adrian and Simon. The frequency-building exercises continued until they achieved 100% accuracy on the same application sets that Adrian and Simon achieved 100% accuracy on when they had demonstrated fluency. These sets were gross motor imitation (application probe set), gross motor imitation whilst standing, gross motor (2 step), and gross motor (3 step). All of these sets are topographically similar to the trained task. Two topographically dissimilar tasks were also tried. These sets were fine motor (2 step) and fine motor (3 step) sets.
Procedure

Baseline, Discrete Trial Training Assessments, and Application Probes

The trainer brought the child in and set the timer to 60-s. On days where reliability checks were taken the trainer started the video camera recording. Both trainer and child sat in their chairs facing each other about 0.6 m apart. Eye contact was established and the trainer said, “Do this”, presented the first motor movement and immediately started the timer counting down. Each motor response made by the boy prompted the trainer to deliver another gross motor movement (from those listed in Table 1.1), but if the child did not respond within 5-s, then the trainer moved onto the next movement on this list. The movements from Table 1.1 were repeated until the timer sounded, completing the interval. No other prompts were given and the whole sequence was run in silence. The trainer wrote down the number of corrects and errors, awarded 2 tokens and then repeated the procedure again. At the end of the second interval the child received 3 more tokens and was allowed to exchange all 5 tokens for an item from the reward tray. Tokens were delivered regardless of performance. The best result of the 2 intervals was charted. If the child displayed any off task or disruptive behaviour (e.g. yelling) the trainer continued to present the items and kept the timer counting down. If the child attempted to get up, or got up, out of his seat then he was brought back and sat down. Each session ran for approximately 5 minutes.
There was one exception to this procedure. When 120-s intervals were completed during the follow up phase only one interval was completed at each session. The baseline phase was run for a minimum of 3 days and until a clear pattern of responding was established.

Discrete Trial Training Procedure

40 discrete trials were run at each session and each discrete trial consisted of: (1) a request to “Do this” followed by the motor movement performed by the trainer; (2) the behaviour the boy performed within 5 seconds of the trainer’s prompts; and (3) the consequences delivered by the trainer. A correct response resulted in the contingent delivery of behaviour specific praise (e.g. “Good clapping Simon, well done.”) and a token. An error resulted in full physical guidance of the correct response, without the delivery of a token or praise. Once the child had accumulated 5 tokens, he was allowed to pick an item from the reward tray.

Each discrete trial training session lasted for approximately 20 minutes. The following four steps were used to teach the children to imitate accurately. The procedures for each step procedure are described using the example of the first two movements (‘clap hands’ first, and ‘place arms up’ second). Step 1: The trainer established eye contact with the child, said, "Do this" whilst clapping and then immediately provided full physical guidance to help the child clap. A
response was scored correct if the child followed the trainer’s guidance, without resistance. The criterion for moving onto step 2 was three correct trials in a row. Step 2: Eye contact was made and the trainer said, "Do this" whilst clapping. If the child clapped within 5 seconds, the behaviour was scored correct, anything else was treated as an error. The criterion for moving onto step 3 was three correct trials in a row. Step 3: Steps 1-2 were then repeated for ‘place arms up’ whilst alternating the movement with the newly learnt ‘clap hands’. The criterion for achieving this step was correct performance for 6 trials in a row (3 times for each movement) without making an error. Step 4: Step 3 was repeated with a new motor movement added one at a time until the child was able to imitate all 10 movements from the list in Table 1.1. Once all 10 motor movements had been presented, the criterion for moving onto frequency-building practice was 3 successive days of 100% accuracy. These sessions were usually run 3 times a week.

These training sessions were then followed by a single 60-s timed baseline assessment of the child’s performance (see baseline procedures described above). The rate of errors and corrects the child made during this timed assessment provided the data for that day.
Frequency-building

The setting was arranged the same as in baseline. The trainer then said, “Do this” and started the timer counting down. During the fluency-building interval the trainer gave enthusiastic verbal praise (e.g. “That’s it, well done”, “You’re doing great, keep going”, and cheering) as a consequence of correct responding but did not give any task-specific prompts (e.g. “Put your arms up”). A review of the videotaped sessions revealed that praise was given for about every 4\(^{th}\) correct imitation. If all 10 motor movements (3 motor movements for Michael and Adam) were performed during the frequency-building interval, then the trainer repeated the movements again until the timer ran out. If the child had performed at a rate faster than 12 per minute, with no errors, then a token was awarded. If the child beat his previous rate then a token was delivered along with enthusiastic praise and encouragement (“You beat your best, well done.”). As part of the procedures, the trainer was prepared to reintroduce discrete trial training if the child’s response rate fell below 12 correct per minute. However, this never happened. Before starting the next interval the trainer wrote down the rate of corrects and errors and reset the golf counter to zero. Once the child had accumulated 5 tokens he was given access to the reward items. Off-task or disruptive behaviour was dealt with in the same manner as in baseline. This procedure was repeated until 10 intervals had been run. This took about 10 minutes when 10-s intervals were used, and up to 30 minutes when 60-s intervals were used. On days when frequency-building and application probes occurred on the same day frequency-building was always completed first.
Results

Adrian and Simon

The performance of the target behaviour under baseline, discrete trial training, and frequency-building conditions are presented in Figures 1.3 and 1.4 for Adrian and Simon respectively (the raw data are presented in appendices A through D). Median scores from each application probe are presented in Table 1.4. During the first baseline phase and the first application probe, neither child imitated any of the movements correctly. Discrete trial training sessions were then introduced and Adrian required 11 sessions (4 weeks) to achieve the accuracy criterion. His performance on the timed assessments show an increase in corrects and a decrease in errors. He achieved a rate of 17(0) by the end of discrete trial training, which was quite slow and a long way short of the frequency aim of 60 correct movements per minute. Simon’s performance under discrete trial training conditions also improved although his best performance, 6(18), was still very slow and inaccurate, even after achieving the accuracy criterion. Incidental observations of Simon’s behaviour during this phase suggested that he often started an assessment imitating correctly, but then either stopped or randomly performed movements. Most of his correct imitations appeared to occur within the first 15 seconds of an assessment.
At the end of discrete trial training both children had improved on 4 of the sets (gross motor movements, fine motor movements, oral motor movements, and gross motor movements whilst standing), and Simon demonstrated some improvements on a further 3 sets (actions with objects, 2 step gross motor movements, and 2 step fine motor movements). The greatest change, for both children was seen on the gross motor movement set, the set that was topographically the most similar to the target behaviour set.

Baseline conditions were then reintroduced for 3 sessions and Adrian’s rate of correct imitations remained in the high teens, although he began to make a few more errors. Simon’s performance was similar to his discrete trial training results.

Next, 10-s frequency-building conditions were introduced and Adrian’s gross motor imitation rate climbed from a moderate 42(18) to a very fast 102(0) with x1.5 celeration in 8 sessions (just under 3 weeks). Simon’s performance responded similarly, climbing from 12(18) to 84(0) with x4.0 celeration in 6 sessions. Both of these performances exceeded the initial estimated frequency aim of 70 correct per minute and, as a result, an application probe was administered. The children demonstrated large improvements across all of the sets barring one, imitating simple drawing, where Adrian’s performance remained unchanged at 0%, and Simon managed to get only one item correct. The data suggest that a frequency aim of 70 correct gross motor imitations per minute, using a practice set of 10 motor movements, was sufficient to achieve
significant generalised imitation skill for both Adrian and Simon. The children were then assessed to see if the gains achieved would maintain over longer intervals (endurance) and after a significant period without practice (retention).

Interval times were increased to 20-s, 30-s, 40-s and then 60-s for the remainder of the frequency-building phase. Adrian’s rate sat at or around 100 per minute with both 20-s and 40-s intervals. Simon’s performance was not as fast (sitting around 70 per minute) nor as steady as Adrian’s (dropping to 46[0], during 60-s intervals, before recovering), but, like Adrian, remained almost error free.
Generally, for both children, the rate of the target behaviour maintained over the longer intervals. As a result baseline conditions were reintroduced and a fourth application probe was taken. Adrian and Simon’s rates maintained at levels achieved during frequency-building and both scored 100% correct on the applications sets (gross motor movements, actions with objects, fine motor movements, oral motor movement, gross motor movements whilst standing, and 2 step gross motor movements). Simon also achieved 100% correct upon the 3 step gross motor movement, and the 3-step fine motor movement sets. Both children’s performances also improved across all of the other remaining sets, except when imitating simple drawing.

Following a 4-week break, the children’s imitation skills were assessed again and both maintained their performances. On some of the sets of movements tested during the application probes both children actually improved following the non-teaching break, which suggests the possibility that unplanned practice had occurred. Interviews with the children’s caregivers confirmed that this had been
the case. 120-s baseline assessments were then tried and Adrian’s rate dropped from approximately 100 per minute to about 75 per minute. Simon’s rate also dropped, falling from 75 per minute to about 60 per minute. Although these ranges of scores represent a decrease in rate, they were still very fast.

At this point both children’s motor imitation skills had demonstrated most aspects of RESAA criteria. They had demonstrated that they were able to maintain the same rate after a period of non-practice, they were able to perform the skill at the same rate over both short (10-s) and long (60-s) intervals, and the initial adduction and subsequent generalised imitation to new movements in the application probes (i.e. adduction of components to form composite repertoires). Another 15 weeks later another baseline phase, plus a sixth application probe, was administered. For both children their target behaviour rate dropped to around 50 to 60 per minute, whereas their percentage scores on the application probes maintained from those scores observed during the fifth probe. Anecdotal reports from both sets of parents suggested that the children had begun imitating and modelling in day-to-day life and had acquired quite a few skills "incidentally" this way. Examples included, throwing a tennis ball to mum or dad, imitating a sibling playing with a skipping rope, and learning to pour a drink by imitating someone else doing it.
Figure 1.3. The number of corrects and errors per minute made by Adrian over the 218 days of the experiment.
Figure 1.4. The number of corrects and errors per minute made by Simon over the 219 days of the experiment.
Table 1.4

The Median Percentage Correct Scores Obtained by Adrian and Simon During the 6 Application Probes

<table>
<thead>
<tr>
<th>Sets</th>
<th>Corresponding Training Phase</th>
<th>Probe 1</th>
<th>Probe 2</th>
<th>Probe 3</th>
<th>Probe 4</th>
<th>Probe 5</th>
<th>Probe 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Motor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adrian’s Mdn</td>
<td></td>
<td>0</td>
<td>40</td>
<td>80</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Simon’s Mdn</td>
<td></td>
<td>0</td>
<td>35</td>
<td>90</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Actions w/ Objects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adrian’s Mdn</td>
<td></td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Simon’s Mdn</td>
<td></td>
<td>0</td>
<td>5</td>
<td>50</td>
<td>100</td>
<td>100</td>
<td>100</td>
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<tr>
<td>Fine Motor Movement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adrian’s Mdn</td>
<td></td>
<td>0</td>
<td>17</td>
<td>58</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Simon’s Mdn</td>
<td></td>
<td>0</td>
<td>0</td>
<td>75</td>
<td>100</td>
<td>100</td>
<td>100</td>
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<tr>
<td>Oral Motor Movement</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Adrian’s Mdn</td>
<td></td>
<td>0</td>
<td>22</td>
<td>88</td>
<td>100</td>
<td>100</td>
<td>100</td>
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<td>Simon’s Mdn</td>
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<td>5.5</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
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<td>Sets</td>
<td>Corresponding Training Phase</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------------</td>
<td>---</td>
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<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Baseline</td>
<td>DTT</td>
<td>Pfmnce aim met</td>
<td>Return to baseline</td>
<td>4 week followup</td>
<td>20 week followup</td>
</tr>
<tr>
<td>Gross Motor w/Standing</td>
<td>Adrian’s Mdn</td>
<td>0</td>
<td>25</td>
<td>85</td>
<td>100</td>
<td>100</td>
<td>100</td>
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<td></td>
<td>Simon’s Mdn</td>
<td>0</td>
<td>40</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Block Patterns</td>
<td>Adrian’s Mdn</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>50</td>
<td>60</td>
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<td>Simon’s Mdn</td>
<td>0</td>
<td>0</td>
<td>60</td>
<td>80</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Simple Drawing</td>
<td>Adrian’s Mdn</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Simon’s Mdn</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Gross Motor (2 step)</td>
<td>Adrian’s Mdn</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Simon’s Mdn</td>
<td>0</td>
<td>5</td>
<td>70</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Gross Motor (3 step)</td>
<td>Adrian’s Mdn</td>
<td>0</td>
<td>0</td>
<td>40</td>
<td>80</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Simon’s Mdn</td>
<td>0</td>
<td>0</td>
<td>60</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Fine Motor (2 step)</td>
<td>Adrian’s Mdn</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>83</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Simon’s Mdn</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>83</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Sets</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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<td></td>
</tr>
<tr>
<td>Corresponding Training Phase</td>
<td>Baseline</td>
<td>DTT</td>
<td>Performance</td>
<td>Return to baseline</td>
<td>4 week followup</td>
<td>20 week followup</td>
<td></td>
</tr>
<tr>
<td>Fine Motor (3 step)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adrian’s Mdn</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>75</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Simon’s Mdn</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
Michael and Adam were trained to determine if similar outcomes were obtainable with fewer exemplars (3 versus 10). Discrete trial training was not conducted because both children could already imitate the movements accurately. A frequency aim of at least 60 correct per minute on the target behaviour was set along with the fluency criterion of having to achieve 100% accuracy on 4 topographically similar generalised imitation sets (gross motor imitation, gross motor imitation whilst standing, 2-step gross motor imitation, and 3-step gross motor imitation). The children practiced until they reached a rate of 60 per minute under 10-s intervals. They then practiced for 6 sessions each (about 14 calendar days) under 20-s and then 30-s intervals, before finally being tried under 60-s intervals.

Michael and Adam’s results are presented in Figures 1.5 and 1.6 (the raw data are presented in appendices E and F) respectively. Table 1.6 shows the percentage of correct imitations corresponding to each fortnightly probe and after the nonteaching break. Figure 1.5 shows that Michael took 82 days to pass the fluency criterion; at which point his rate on the target behaviour had reached a very high 114(0). Frequency-building continued for 2 weeks after this with Michael’s rate peaking at an extremely fast 144(0). This rate was double the rate Simon and Adrian had reached when they achieved 100% accuracy on the same 4 sets of movements under application probe conditions. Figure 1.6 shows that Adam passed the criterion in even shorter time, meeting the fluency criterion on
day 54. Adam’s rate at the time was 216(0) - which was incredibly fast and three times as fast as Adrian or Simon. Both Michael and Adam retained: (1) the rate and accuracy of the target skills; and (2) the accuracy of topographically similar motor imitation skills following 46- and 25-days, respectively, without practice or testing. Both children failed to show improvements on 2 and 3-step fine motor imitation.
Figure 1.5. The number of corrects and errors per minute made by Michael over the 207 days of the experiment.
Figure 1.6. The number of corrects and errors per minute made by Adam over the 138 days of the experiment.
Table 1.6

The Percentage Correct Scores Obtained by Michael and Adam During Each Fortnightly Application Probes and After A Nonteaching Break

<table>
<thead>
<tr>
<th>Sets</th>
<th>Probe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Gross Motor</td>
<td></td>
</tr>
<tr>
<td>Michael</td>
<td>40</td>
</tr>
<tr>
<td>Adam</td>
<td>40</td>
</tr>
<tr>
<td>Gross Motor w/Standing</td>
<td></td>
</tr>
<tr>
<td>Michael</td>
<td>25</td>
</tr>
<tr>
<td>Adam</td>
<td>25</td>
</tr>
<tr>
<td>Gross Motor (2 step)</td>
<td></td>
</tr>
<tr>
<td>Michael</td>
<td>10</td>
</tr>
<tr>
<td>Adam</td>
<td>40</td>
</tr>
<tr>
<td>Gross Motor (3 step)</td>
<td></td>
</tr>
<tr>
<td>Michael</td>
<td>0</td>
</tr>
<tr>
<td>Adam</td>
<td>20</td>
</tr>
<tr>
<td>Fine Motor (2 step)</td>
<td></td>
</tr>
<tr>
<td>Michael</td>
<td>0</td>
</tr>
<tr>
<td>Adam</td>
<td>0</td>
</tr>
<tr>
<td>Fine Motor (3 step)</td>
<td></td>
</tr>
<tr>
<td>Michael</td>
<td>0</td>
</tr>
<tr>
<td>Adam</td>
<td>0</td>
</tr>
</tbody>
</table>
All 4 children demonstrated that imitation skills taught to children with autism responded to frequency-building procedures in ways that are consistent with previous successful applications of fluency-based training and behavioural fluency theory. As a consequence the data also show that the procedures used here allowed the children to attain rates high enough to achieve RESAA outcomes. Simon and Adrian’s data also showed that by combining discrete trial training with frequency-building practice there were larger gains in generalised imitation than with discrete trial training alone. Following discrete trial training generalised imitation was restricted to topographically similar movements. This observation was consistent with the findings from previous studies (Garcia et al., 1971; Young et al., 1994). Following the additional frequency-building component the accuracy of generalised imitation improved on measures of topographically similar movements and, even more significantly, had generalised to topographically dissimilar movements. These data supports training to fluency using frequency-building procedures as a viable method to overcome the significant problems educators have in promoting generalised imitation in young children with autism. These observations are consistent with descriptions of skill adduction and application by Binder (1996) and Johnson and Layng (1992; 1994), and provide a good data based account of the generative outcomes associated with skills taught to fluency. Finally, the data show Michael and Adam achieved very high rates of accurate imitation, with only 3 exemplars, when exposed to frequency-building procedures. However, both children only
showed generalised responding with topographically similar movements. These results tentatively suggest that more examples appear to be better than fewer for promoting generalisation and fluency and are consistent with previous assertions (Binder, 1996; Haring et al., 1985; Johnson & Layng, 1992; 1994; Stokes & Baer, 1977; White et al., 1988). Finally, caregiver reports suggest that all 4 children were applying many of these skills to situations outside of the training setting.

One peculiar observation was the large difference between the rates the children reached before they achieved the fluency criteria. The children taught with fewer exemplars: (1) did not meet criteria until their rates reached frequency aims that were double to triple the rate of the children taught with more exemplars, (2) required more practice sessions to achieve generalised imitation to topographically similar movements, and (3) failed to generalise to topographically dissimilar forms. The data obtained here also suggest that discrete trial training with 10 exemplars took fewer training sessions, hence was more efficient, than frequency-building with 3 exemplars to achieve generalised imitation across topographically similar forms. These findings extend what is known about frequency aims and skill generalisation. Stokes and Baer (1977), Stokes and Osnes (1989), and White et al. (1985) cite examples of discrete trial training to illustrate that generalisation can be improved by using multiple exemplars during training. The current findings extend this suggestion to the technology of behavioural fluency. Although these conclusions require further experimental evidence to test the robustness of these observations, the differences observed here were both consistent and large enough to warrant
discussion. The observations also present as an interesting hypothesis that the pay-off for using more exemplars during training is: (1) a lower frequency aim, and (2) increased adduction, application, and generalisation. If supported by further inquiry this hypothesis provides very useful information about the nature of generalised imitation and contributes to the knowledge of independent variables that affect fluent skill development.

One possible confound may have occurred during the application probes. During each probe, a break happened after all of the items from an imitation set had been presented to the child. This sequence would often result in response contingent escape following a correct response of his could have influenced responding, although the children were not required to respond correctly. Therefore, it’s impossible to say whether or not this contingency influenced the results. Nevertheless, this contingency is controlled for in the proceeding experiments.

In light of the results of this experiment two further procedural modifications will be introduced for the remaining experiments. Firstly, rate measures will be taken during application probes. By using rate measures the data might reveal further changes in generalised imitation from probe to probe. The other advantage is that rate is a much more sensitive measure to behavioural changes than percentage correct scores (Binder, 2001; Lindsley, 1999). Secondly, the amount of instruction time per session will be the same for all frequency-building sessions. In the current experiment, because each session ran for 10 intervals, a 30-s interval phase resulted in 3 times the amount of instruction time compared to a 10-s interval phase. In the following experiments the amount of time
allocated to each frequency-building session will be the same, regardless of the length of the intervals used during each session. This means that if one session contains twelve, 10-s intervals, then a session of 30-s intervals will contain only four intervals. In both cases each session results in 120-s of instruction time.

In extending the procedures of the current experiment, the next experiment will implement these changes with a new skill and with new learners. The aim will be similar to the current experiment that is to examine the effects of frequency-building on skill acquisition whilst probing for applications. The target behaviour will be line tracing with application probes to more complex tracing tasks and free drawing exercises.
EXPERIMENT 2: USING FREQUENCY-BUILDING TO TEACH CHILDREN WITH AUTISM TO TRACE OVER TALLY SLASHES WHILST PROBING FOR APPLICATIONS TO TRACING AND COPYING NUMBERS AND LETTERS

Introduction

Many learners with developmental disabilities experience difficulties when learning to write (Graham & Harris, 2000). Problems can often arise because students have failed to gain fluency on component skills (Graham, 1999; Johnson & Layng, 1992). Graham (1999) reviewed the literature on effective handwriting instruction and identified several major skill components thought necessary for the development of fluent writing. Two major components identified by Graham (1999) were: (1) writing tally slashes and circles fluently, and (2) accurately tracing over correctly formed tally lines, shapes, letters or words. Tracing tally slashes, which requires a single downward stroke, could be a component skill for tracing more complex letters that require more movements to be formed correctly (e.g. “t”, “h”, “n”). Learners have also benefited from learning to trace single lined letters first (e.g.,“I” and “l”) before moving onto more complex letters (Graham & Harris, 2000).

In the current experiment tracing tally slashes will be practiced using frequency-building strategies. The main aim of this experiment is to determine if the skill
of tracing tally slashes when taught to young children with autism responds to frequency-building procedures in ways consistent with previous successful applications of fluency-based training. Secondly, the experiment aims to determine if this practice affects the performance of tracing letters, copying drawings, and copying text. Thirdly, the experiment aims to provide a data based analysis of Graham’s (1999) claim that tally slash tracing is a good foundational skill for writing.

Following on from experiment 1, two procedural modifications will be introduced for this experiment. Firstly, rate measures will be taken during application probes. By using rate measures the data might reveal other changes in applications from probe to probe. The other advantage is that rate is a much more sensitive measure to behavioural changes than percentage correct scores (Binder, 2001; Lindsley, 1999). Secondly, the amount of instruction time per session will be the same for all frequency-building sessions. In experiment 1, because each session ran for 10 intervals, a 30-s interval phase resulted in 3 times the amount of instruction time compared to a 10-s interval phase. In all of the remaining experiments the amount of time allocated to each frequency-building session will be the same, regardless of the length of the intervals used during each session. This means that if one session contains twelve, 10-s intervals, then a session of 30-s intervals will contain only four intervals. In both cases each session results in 120-s of instruction time.
Method

Selection Criteria and Participants

Two children were selected according to the criteria used in experiment 1.

Mark

Mark was 3 years and 4 months of age at the commencement of the experiment. He had been diagnosed with autism and had been independently labelled with Kanner's syndrome. An independent psychometric assessment indicated that he passed all items on the Leiter International Performance Scale (Leiter, 1959) up to 4 years and passed 2 items assessed at the 5-year level. This placed his performance IQ in the "superior" range. He was also assessed using the Peabody Picture Vocabulary Test and managed to reach the 2-year level of performance. Before commencing the experiment Mark had received about 18 months of applied behaviour analysis discrete-trial intervention, at 12 hours per week. During this time he had learned many skills (e.g. some phonemes, toileting, imitation, naming). He had used pens and other writing tools prior to this
experiment; however his letter writing accuracy was very poor. He rarely drew in his own free time and, when he did, it was mostly scribble. He often displayed bizarre vocalisations, with occasional echolalia, and rarely engaged appropriately with others. He occasionally threw severe tantrums and lacked normal interpersonal and social communication skills.

Justin

Justin was a 5-year-old autistic boy with some speech. Independent reports described him as very active and included hyper-activity as a major concern. A psychometric assessment, using the WPPSI-R and the Leiter International Performance Scale, had placed him in the borderline range for intelligence. A home based ABA program had been running for 18-months at 6 hours per week prior to commencing this experiment. Progress reports from his programme had indicated that he was inconsistent in his behaviour and there were some days when it was very difficult to keep him on-task. As a part of his curriculum he had been taught to trace tally slashes and letters when asked, however he was very slow and inaccurate. He did draw in his free time, however it was mainly scribble. In his program he had also been taught to say 10 sounds when presented with the written letter and to perform the verbal request “point with your finger” when asked to.
Setting and Materials

The setting at each child’s home was the same as in experiment 1, except the video camera was not included and a child-sized table was added. The children practiced tracing tally slashes using a practice sheet that featured 180, 2cm tally slashes, spaced 2cm apart from each other in 6 rows of 30. These were printed on 29.5 cm x 42 cm sheets of white paper in ‘landscape’ position. During practice the children used a medium point felt tipped marker to trace over the tally slashes. To score the accuracy of the traced tally slashes the teacher used a clear plastic overhead transparency sheet that featured 180 boxes. When overlaid onto the practice sheets, placed a 6-mm wide by 26-mm high box around each of the 2-cm tally slashes.

To assess for applications to other forms and letters, 8 additional work sheets were created. Each sheet was printed in black ink on 29.5 cm x 21 cm sheets of white paper, in landscape position. 5 of these sheets were designed to be traced over by the children and included one sheet of zeros, one sheet of 2cm tally slashes at varying angles (e.g., \, /, |, --) one sheet of letters composed with straight lines (e.g., k,l,t,A,T, and L), one sheet of letters composed with a curve (e.g., b, c, d, e, B, C, and G), and a sheet containing the numbers 0 through 9. All of the items used on these sheets are presented in Figure 2.1. A marking key was made for each of the 5 tracing sheets constructed from clear overhead transparency sheets that placed a 6-mm wide border around the lines or text. The other 3 sheets had the alphabet in upper case printed on one, the alphabet in lower case print printed on another, and the numbers 0 through 9 printed on the third sheet. The text was printed in 24 point-sized, Comic Sans MS style font.
Figure 2.1. The pool of items used in the tracing application probes in experiment 2.
Response Definitions and Target Behaviour

A child’s attempt to trace or copy had to finish before the timer sounded (the end of the interval) for the attempt to be counted. Tracing was scored correct if the pen mark made by the child fell within the borders set by the appropriate marking key. For the copying assessments, the teacher judged whether each letter or number was properly formed and whether he could recognise it.

Data Collection and Interobserver Agreement

The two dependent measures used in this experiment were the number of corrects and the number of errors made per interval, expressed as a count per minute score. The best performance from the day’s session was charted (the criteria used here for selecting the best performance were the same as used in experiment 1).

Interobserver agreement checks were conducted on all of the tracing items using the same methods as outlined in experiment 1 except the two observers independently marked the children’s work using the marking key rather than using video footage. For the assessments of the children’s copying skills both observers independently judged whether or not each letter was recognisable and then compared their scores. If there were a discrepancy, then they would both re-
score the work until consensus was achieved. Table 2.1 shows the percentage of data that was checked for reliability across both children and over the phases of the experiment.

Experimental Design

The effects of frequency-building were assessed using an ABA design, with long-term follow-up as shown in the flowchart below. Application probes were administered when the rate of the target behaviour reached the frequency aim of 60, 80, and 100 corrects per minute. A rate of 100 correctly traced tally slashes per minute was selected as the fluency aim because this was the rate at which an adult could complete the task. The rates of 60 and 80 corrects per minute were chosen arbitrarily to provide snapshots of a skill developing fluency. Application probes always followed frequency building training on those sessions when the children were tried on both procedures. The return to baseline phase was introduced when the following criteria were met: (a) a rate greater than 100 correct tally slashes traced per minute and (b) a rate of 30 correct per minute upon the application probe “straight lined letters”.

<table>
<thead>
<tr>
<th>Baseline</th>
<th>Frequency Building</th>
<th>Baseline</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application Probes</td>
<td>Application Probes</td>
<td>Application Probes</td>
<td>Application Probes</td>
</tr>
</tbody>
</table>
Table 2.1

The Percentage of Data Checked for Reliability in Experiment 2

<table>
<thead>
<tr>
<th>Phase</th>
<th>Child</th>
<th>Baseline</th>
<th>Frequency Building</th>
<th>Application Probes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mark</td>
<td>40%</td>
<td>43%</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>Justin</td>
<td>33%</td>
<td>47%</td>
<td>33%</td>
</tr>
</tbody>
</table>
Procedure

Baseline

The procedure for baseline assessments was the same as experiment 1 except the teacher sat facing the child, on the opposite sides of a table, about 1-m apart. The timer was set to 60-s and a practice sheet was placed in front of the child. The teacher then handed the child a marker and gave the command, “Trace the lines”. The teacher then immediately started the timer counting down. The beep of the timer sounded and the teacher removed the work sheet. A practice sheet was placed in front of the boy and the procedure was repeated once more for another 60-s.

Application Probes

Mark

Performance on each of the 8 worksheets was assessed using the same procedures as baseline. For each of the 5 tracing sheets, the teacher set the timer to 60-s, said, “Trace the drawing” and started the timer counting down. When
the timer sounded the teacher gathered the work sheet and replaced it with another copy of the same work sheet, repeating the probe a second time. For copying, two A4 sheets of paper, in landscape position, were placed in front the child. One of them was the work sheet, the other a blank sheet of paper. The teacher then said, “Copy these <pointing to the letters or numbers page> onto here <pointing to the blank page>” as a prompt to begin. The procedure was then repeated a second time.

Justin

For Justin the application probes procedures were identical to Mark’s except he was given twelve, 10-s intervals.

Frequency-building

Frequency-building sessions were similar to the frequency-building procedures used in experiment 1 except the procedures were repeated until the sum of the intervals equalled 120-s. (For example, if each interval were 10-s long, then 12 intervals were run during that session.) The task used here required the child to “Trace the lines”.
Results

The results are presented in Figures 2.2 and 2.3 and Tables 2.2 and 2.3 for Mark and Justin (the raw data are presented in appendices H through I). At baseline and during the first application probe both children performed slowly and inaccurately. Mark, made about half as many errors as corrects and achieved rates that varied between 42(32) and 50(25). These rates were all well short of the frequency aim of 100(0). He scored low rates, less than 10 correct per minute, on the application probes across all sets except when he “traced angled lines” where he scored 23(20). Justin, on the other hand, made about twice as many errors as corrects and scored between 16(31) and 21(33) during baseline. His performance during the application probe was similar to Mark’s, with his highest rate scored when he “traced angled lines” (36[18]).

10-s frequency-building intervals were then introduced and Mark and Justin’s rates climbed to a moderate 60(0) in 5 days. In application probes Justin demonstrated an increase in rate when he traced zeros, traced angled tally slashes, traced straight lined letters, and traced curved letters. Mark also demonstrated improvements by doubling his rate from the first application probe on the sets “traced angled lines” and “traced straight lined letters”. Examples of Mark’s work from this time can be seen in Figure 2.4. When both children attempted to copy items during the application probe their rates remained at, or near, zero.
30-s frequency-building intervals were then tried and both children’s error counts increased and their rate of correct counts dropped. Justin’s data, in particular, shows a clear drop in performance, when his rate went from 32(4) to 22(12) in 4 sessions. With the reintroduction of 10-s intervals their performances immediately returned to around 60(0) and then continued to show positive celerations, with Mark’s rate peaking at a high 84(0) and Justin’s reaching 90(0). A second phase of 30-s intervals was introduced and both children’s rates decreased, however the effect was most noticeable on Justin’s performance. Justin’s rate dropped to 42(6), with errors remaining for nearly two weeks before his rate began to increase again. Mark’s data showed that errors returned for the first 2 days of 30-s intervals, before his performance matched that achieved during the 10-s intervals. On day 77, after three weeks of 30-s intervals, Mark was tried on 60-s intervals to test whether his rate would maintain. There was an initial return of some errors and a reduction in his corrects per minute, however after two weeks his rate had returned to levels of 80 per minute or higher. When both children achieved 80 per minute or higher a third application probe was administered and both Mark and Justin demonstrated increases in the rate of their performances on all of the tracing assessments. Mark, in particular, demonstrated multiple improvements, with some rates being 6 to 8 times faster than the previous application probe. However, neither child showed any improvements on the copying assessments and continued to score around the 0 correct per minute mark.
Figure 2.2. The number of corrects and errors per minute made by Mark over the 150 days of the experiment.
Table 2.2

The Median Rate of Corrects and Errors Obtained by Mark Over the 5 Application Probes in Experiment 2

<table>
<thead>
<tr>
<th>Probe</th>
<th>Sets</th>
<th>Phase</th>
<th></th>
<th></th>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>Traced Zero’s</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Mdn</td>
<td></td>
<td></td>
<td>3(29)</td>
<td>5(15)</td>
<td>20(2)</td>
<td>50</td>
<td>39</td>
</tr>
<tr>
<td>Range (correct)</td>
<td></td>
<td></td>
<td>2 – 4</td>
<td>4 – 6</td>
<td>19–21</td>
<td>46-51</td>
<td>37-43</td>
</tr>
<tr>
<td>Traced Angled Tally slashes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Mdn</td>
<td></td>
<td></td>
<td>23(20)</td>
<td>40(15)</td>
<td>86</td>
<td>77</td>
<td>69</td>
</tr>
<tr>
<td>Range (correct)</td>
<td></td>
<td></td>
<td>15-30</td>
<td>36-50</td>
<td>85-90</td>
<td>75-79</td>
<td>59-74</td>
</tr>
<tr>
<td>Traced Straight Lined Letters</td>
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<td>Mdn</td>
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<td></td>
<td>5(21)</td>
<td>10(9)</td>
<td>28</td>
<td>34</td>
<td>27</td>
</tr>
<tr>
<td>Range (correct)</td>
<td></td>
<td></td>
<td>4 - 5</td>
<td>6 – 10</td>
<td>24-29</td>
<td>31-34</td>
<td>19-35</td>
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<tr>
<td>Traced Curved Letters</td>
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<tr>
<td>Mdn</td>
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<td>3(20)</td>
<td>3(17)</td>
<td>26(3)</td>
<td>33(1)</td>
<td>31</td>
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<tr>
<td>Range (correct)</td>
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<td></td>
<td>2 – 4</td>
<td>2 – 4</td>
<td>23-34</td>
<td>31-39</td>
<td>28-35</td>
</tr>
<tr>
<td>Traced Numbers 0-9</td>
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<tr>
<td>Mdn</td>
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<td>7(26)</td>
<td>6(22)</td>
<td>33(8)</td>
<td>36</td>
<td>35</td>
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<td>Range (correct)</td>
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<td>4 – 7</td>
<td>5 – 7</td>
<td>30-35</td>
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<td>Baseline</td>
<td>60/min in 10-s</td>
<td>80/min in 60-s</td>
<td>100/min in 60-s</td>
<td>Follow-Up</td>
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<tr>
<td>Mdn</td>
<td>1(5)</td>
<td>1(5)</td>
<td>1(5)</td>
<td>1(5)</td>
<td>1(5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range (correct)</td>
<td>0 – 1</td>
<td>0 – 1</td>
<td>0 – 1</td>
<td>0 – 1</td>
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<td>0(7)</td>
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<td>Range (correct)</td>
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<td></td>
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<td>Mdn</td>
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<td>1(3)</td>
<td>1(3)</td>
<td>1(3)</td>
<td>1(3fs)</td>
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</tr>
<tr>
<td>Range</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note.** Range values left blank indicate that the median value was scored on every attempt.

aThe values in parentheses are the errors per minute score obtained with the median rate corrects per minute score.
Figure 2.3. The number of corrects and errors per minute made by Justin over the 138 days of the experiment.
Table 2.3

The Median Rate of Corrects and Errors Obtained by Justin Over the 5 Application Probes in Experiment 2

<table>
<thead>
<tr>
<th>Sets</th>
<th>Probe</th>
<th>Phase</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Baseline</td>
<td>60/min in 10-s</td>
<td>80/min in 30-s</td>
<td>100/min in 60-s</td>
</tr>
<tr>
<td>Traced Zero’s</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mdn</td>
<td></td>
<td></td>
<td>12(24)</td>
<td>30</td>
<td>54</td>
<td>60</td>
</tr>
<tr>
<td>Range (correct)</td>
<td></td>
<td></td>
<td>24-30</td>
<td>60-66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traced Angled Tally slashes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mdn</td>
<td></td>
<td></td>
<td>36(18)</td>
<td>48</td>
<td>66</td>
<td>84</td>
</tr>
<tr>
<td>Range (correct)</td>
<td></td>
<td></td>
<td>30-36</td>
<td>48-60</td>
<td>84-90</td>
<td></td>
</tr>
<tr>
<td>Traced Straight Lined Letters</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mdn</td>
<td></td>
<td></td>
<td>0(6)</td>
<td>18</td>
<td>24</td>
<td>36</td>
</tr>
<tr>
<td>Range (correct)</td>
<td></td>
<td></td>
<td>24-30</td>
<td>30-42</td>
<td>36-42</td>
<td></td>
</tr>
<tr>
<td>Traced Curved Letters</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mdn</td>
<td></td>
<td></td>
<td>0(6)</td>
<td>12</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Range (correct)</td>
<td></td>
<td></td>
<td>24-30</td>
<td>30-36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traced Numbers 0-9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mdn</td>
<td></td>
<td></td>
<td>18(12)</td>
<td>18(18)</td>
<td>24</td>
<td>36</td>
</tr>
<tr>
<td>Range (correct)</td>
<td></td>
<td></td>
<td>36-42</td>
<td>36-42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sets</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>------</td>
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<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Phase</td>
<td>Baseline</td>
<td>60/min in 10-s</td>
<td>80/min in 30-s</td>
<td>100/min in 60-s</td>
<td>Follow-Up</td>
<td></td>
</tr>
</tbody>
</table>

Copied Uppercase Alphabet

- **Mdn**: 0(6) 0(6) 0(6) 0(6) 0(6)
- **Range (correct)**: 0(6) 0(6) 0(6) 0(6) 0(6)

Copied Lowercase Alphabet

- **Mdn**: 0(6) 0(6) 0(6) 0(6) 0(6)
- **Range (correct)**: 0(6) 0(6) 0(6) 0(6) 0(6)

Copied Numbers 0-9

- **Mdn**: 0(12) 0(12) 0(12) 0(12) 0(12)
- **Range**: 0(12) 0(12) 0(12) 0(12) 0(12)

**Note**: Range values left blank indicate that the median value was scored on every attempt.

aThe values in parentheses are the errors per minute score obtained with the median rate corrects per minute score.
Figure 2.4. Examples of Mark’s work from the application probes in experiment 2.
Frequency-building intervals were then continued for two more weeks. Mark’s performance under 60-s intervals continued to climb, peaking at 118(0). Justin’s performance under 30-s intervals also increased to over 100 per minute, and maintained at these rates with the introduction of 60-s intervals. Both children were then tried under baseline conditions and their rates demonstrated endurance by maintaining at, or above, 100 per minute.

After achieving the target rate a fourth application probe revealed that the children’s rates on the tracing assessments maintained at levels similar to those achieved during the third application probe. Mark’s performance was notable with a large improvement in his rate when tracing zeros (climbing from 20 to 50 per minute). Justin also showed an increase in his rate when he traced angled tally slashes (climbing from 66 to 84 per minute). Again, the children did not complete any of the copying items.

Following a non-teaching break of about 3 weeks, both Mark and Justin retained the rates they had previously achieved on the target behaviour and on most of the application probes. Mark showed the exceptions to this with some reductions in his rate when he traced zeros, traced angled tally slashes, and traced straight lined letters.
The findings showed that the rate and accuracy of the target behaviour increased over time when practiced under frequency-building conditions. Concurrently, the rate and accuracy of letter and number tracing also increased at each of the application probes. Further still, the rate of response for all of these skills retained following a period of nonpractice.

The data also show that applications happened before endurance. For both children the measured applications peaked when the rate of the target behaviour had reached or exceeded 80(0) per minute. This seemed to indicate when tracing had become fluent enough to allow for clear improvement in the application of tracing skills to letters and numbers. However, to achieve skill endurance further practice was required and happened only when both children reached 100(0) per minute.

The data also showed that high rates of tracing tally slashes made no impact upon any of the freehand copying probes. This observation suggests that tracing tally slashes fluently is insufficient to promote adductions and application to freehand copying skills and, as suggested by Graham (1999), may require that other skills such as freehand tally slash and circle writing are also fluent.

An alternative explanation for performance rates increasing at each successive application probe may have been because each application assessment resulted in
contingent escape. However this negative reinforcement was based on an interval schedule and response independent, unlike experiment 1 where completing all the items resulted in escape. Therefore, even if escape consequences were powerful enough to promote change, it was unlikely in the current experiment because escape was not contingent upon number of responses but happened with the passing of time. The data collected here then suggest that the changes in the application probes are most likely to have been related to the practice and rate increases in the target behaviour under frequency-building conditions. At this stage this conclusion is only tentative and will be tested and addressed in later experiments. With replication and better control, a stronger conclusion will be able to be made.

In this experiment the amount of instruction time per session was equal regardless of the interval length so it is also possible to rule out that the amount of practice per session caused any changes. This modification meant that it can only be the changes in the interval times that can account for the changes in the children’s rate of response – rather than a change in the amount of practice completed each day. Therefore the data can support the premise that rate and accuracy vary significantly as a function of the length of the interval, at least during the early stages of training and within the procedural confines of the current experiment. This observation is consistent with data collected by Binder et al. (1990) who corrected slow, inaccurate responding by introducing shorter intervals. With repeated practice, however, they found that the rate of response eventually endured over longer intervals. Again, the data collected here support those findings.
The following experiments will aim to replicate and extend the current experimental design across different skills. This will be done to uncover factors that may determine fluency and help to explain the mechanics of frequency-building procedures. The next experiment will provide frequency-building practice to writing tally slashes and o-loops whilst probing the speed and accuracy of writing the alphabet.
EXPERIMENT 3: USING FREQUENCY-BUILDING TO TEACH CHILDREN WITH AUTISM TO FREE-WRITE O-LOOPS AND TALLY SLASHES WHILST PROBING FOR APPLICATIONS TO WRITING THE ALPHABET

Introduction

The results from the previous experiment showed that tracing tally slashes to fluency promoted applications to letter and number tracing. However, applications did not extend to freehand writing skills. Graham’s (1999) review suggested that proficiency in writing tally slashes and o-loops might support the development of fluent handwriting skills. In this sense, forming tally slashes and o-loops at a high and accurate rate could be a component skill for applications to writing the alphabet. Following on from the procedures and protocols used in the previous experiment, the current experiment aims to use frequency-building strategies to promote the speed and accuracy of free-writing tally slashes and o-loops. As learners demonstrate increases in their rate of response probes will be administered to test for applications to writing of the alphabet. Freeman and Haughton (1993b) suggested frequency aims for both of these skills, based on sampled rates from nonautistic populations. These aims were to free-write o-loops at a rate of 300+ per minute, and to free-write tally slashes at a rate between 250 and 400 per minute.
The main aim of this experiment is to determine if freehand tally slashes and o-loop writing skills taught to young children with autism can be respond to frequency-building procedures in ways consistent with previous successful applications of fluency-based training. Secondly, this experiment aims to determine if the frequency aims gathered from studies of nonautistic populations can be used to set frequency aims for young children with autism when free-writing tally slashes and o-loops. Thirdly, this experiment aims to determine if this practice affects the performance of freehand letter and number writing skills. The final purpose for this study is to provide a data based analysis of Graham’s (1999) claim that freehand o-loop and tally slash writing is a component skill of handwriting.

Method

Selection Criteria and Participants

The selection criteria used here were similar to those used in the preceding experiments, with the addition that the two boys were also selected specifically because of their emerging writing skills characterised by slow and inaccurate freehand printing skills.
Neil

Neil was a 4-year and 8-month old boy with autism. On an independent assessment of his abilities he answered all the items up to the 3½ year level on the Leiter International Performance Scale (Leiter, 1959) placing him in the below average range. In his home based ABA program, which had been running for 2 years at approximately 6 hours per week, his case managers suggested that occasionally he would fail to follow requests, however this was not a persistent problem and had only occurred at a frequency of about once a fortnight. Neil had achieved proficient gross motor skills and some early academic skills. For example, when shown printed letters Neil named every letter of the alphabet. Neil could write the alphabet but often needed some prompting to complete the task. Examples of Neil’s handwriting, taken before the experiment, can be found in Figure 3.1. This attempt was timed and it took Neil 120-s to write A, B, C, and D. His fine motor skills were slow and clumsy and he had trouble manipulating small objects (such as a pencil).

Chris

Chris was a 6-year-old autistic boy who was echolalic in his speech. He had received approximately 8 hours per week of one-to-one intervention for more than 18 months in a home-based ABA programme. He followed strict routines in
daily activities and displayed severe tantrums when his routines were disturbed. He often displayed a flat affect and voice, and showed poor compliance to requests across most situations. On an independent psychological assessment Chris demonstrated very good matching skills and excellent visuo-spatial skills (as measured by the WPPSI-R and the Leiter International Performance Scale). His motor skills, however, were a noted weakness and he showed some problems holding and manipulating a pen or pencil. Chris had written the alphabet letters before but often needed prompting to complete the sequence and was slow and inaccurate.
Figure 3.1. Neil’s Handwriting From a Pre-test Assessment.

Note. The first 4 letters took 60 seconds to complete.
Setting and Materials

The setting in this experiment was identical to experiment 2 with the inclusion of the video camera used in experiment 1. The camera was angled down, pointing directly at the tabletop. Extra materials included in this experiment were blank sheets of white, A3 sized paper and a medium sized point, felt tipped pen.

Target Behaviour and Response Definitions

The target behaviours were free-writing tally slashes and o-loops. An o-loop was scored correct when the boy drew one full arc that intersected itself after a full 360 degrees. The next o-loop could be completed without the pen leaving the paper. Figure 3.2 shows an example of Neil’s o-loop writing, with multiple o-loops drawn over and over each other. A tally slash was scored correct when the boy made a single mark, either upward or downward, with his pen. Tally slashes could be made without the pen leaving the paper with a continual up and down movement of the pen. A single up-and-down pen mark was scored as 2 correct movements. For both o-loops and tally slashes, pen marks that did not fit these definitions were defined as errors. Each child was also assessed on writing letters of the alphabet. For Neil this included both upper- and lower-case letters whereas for Chris only upper case letters were assessed. A letter was scored correct if the trainer judged that the letter was properly formed and recognisable.
Figure 3.2. An example of Neil’s o-loop writing during frequency-building.
Data Collection and Interobserver Agreement

The two dependent measures, number of corrects and numbers of errors made per interval, were collected and charted using the same procedures as in experiment 2.

The target behaviour scores were checked for interobserver agreement using the same video scoring procedures as used in experiment 1. The data taken from the alphabet writing assessments were checked using the same interobserver agreement procedures as used in experiment 2. Table 3.1 shows the percentage of data that were checked for reliability across the two children over the different phases of the experiment.
Table 3.1

The Percentage of Data Checked for Reliability in Experiment 3

<table>
<thead>
<tr>
<th>Phase</th>
<th>Child</th>
<th>Baseline</th>
<th>Frequency Building</th>
<th>Application Probes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neil</td>
<td>45%</td>
<td>37%</td>
<td>40%</td>
<td></td>
</tr>
<tr>
<td>Chris</td>
<td>43%</td>
<td>40%</td>
<td>33%</td>
<td></td>
</tr>
</tbody>
</table>
Experimental Design

The effects of frequency-building on tally slash and o-loop writing skills were investigated using an ABABA design, with long-term follow up. Concurrent application probes of freehand alphabet writing rate were taken approximately 3 times a week (with the exception of 2 weeks during the first frequency-building phase). On these days the order of instruction was frequency-building and then the application probe. The purpose of these probes was to provide a continual measure to monitor any concurrent changes in freehand writing. The design for the experiment is illustrated in the following flow chart.
Procedure

Baseline

The procedures for baseline assessments were the same as experiment 2. The timer was set to 60-s and a 29.5 cm x 42 cm sheet of paper was placed in front of the child. The trainer then handed the child a marker and gave the command, “Draw lines”. The timer then immediately started the timer counting down. The beep of the timer sounded and the trainer removed the work sheet. This procedure was then repeated once more and the child was then allowed access to the reward tray. Following this two “Draw circles” trials were completed using the same procedures.

Application Probes

The trainer set the timer to 60-s and sat down at the table with the boy. The trainer placed an A3 sized sheet of blank paper in front of the boy, handed him a felt-tipped pen, said, “Write the alphabet” and then started the timer. The beep of the timer sounded and the trainer removed the sheet of paper. The trainer then placed a new sheet of paper in front of the boy and repeated the procedure a second time. The child was then given access to the reward tray. Neil was run
through this entire procedure a second time to test writing of lower case letters.
The instructions given to Neil were “Write upper case letters” and “Write lower case letters”.

**Frequency-building**

The frequency-building procedures were the same as used in experiment 2, except the children were asked to “Draw lines”, and to “Draw circles”. All frequency-building intervals were 10-s. A review of videotapes from the sessions showed that verbal praise and encouragement was for about every 6th correct response during an interval. At the end of the interval the child was awarded a token when he beat his rate from the previous interval. Once the child had accumulated 5 tokens he was given access to the reward tray at the following break.

**Results**

The results are presented in Figures 3.3 and 3.4 for Chris and Neil respectively (the raw data are presented in appendices J through K). During the first baseline phase both children drew tally slashes at a rate less than 100 per minute, and drew o-loops at a rate less than 40 per minute. Their performances on the
application probes were very slow with both children only managing 1 or 2 correct letters in 60-s. During frequency-building sessions, Chris’ tally slashes rate increased from 96 to a very fast 204 per minute and his o-loop rate climbed from 36 to a fast 138 per minute. Similarly, Neil’s tally slashes went from baseline levels to 300 per minute, and his o-loops increased from 42 to 267 per minute. On the way to attaining these rates, both children’s data showed sudden jumps or leaps in performance, rather than a steady increase that progressed uniformly from day to day. Chris’ o-loop rate showed x1.9 celeration and jumped from 42 to 78 in one week (days 12 through 20). A larger increase was achieved at days 53 through 55 when his tally slash rate showed x3.0 celeration and went from 138 to 222. Neil’s o-loop rate changed similarly, with the most noticeable example being when his rate jumped from 72 to 156 in two days (days 59 and 60, a huge celeration of x5.0).

Application probes of alphabet writing taken at this time show a positive celeration, although both children’s performances were still relatively slow. Chris’ rate had climbed from 3(4) per minute on day 34, to 7(0) per minute by day 69. Neil’s uppercase rate moved from 2(3) per minute on day 17, to 15(0) per minute on day 82, and his lowercase rate increased from 1(3) per minute on day 17, to 7(2) on day 82. Neil’s data, in particular, also show a strong covariation between his o-loop writing performance under frequency-building conditions and his uppercase alphabet writing performance under application probe conditions.
Baseline conditions were then introduced for 14 days, on day 86 for Neil and day 74 for Chris, and apart from Neil’s o-loop writing performance, both children showed noticeable drops in their rate on tally slash, o-loop, and alphabet writing tasks, showing $\pm 2$ to $\pm 2.5$ celerations.

With the reintroduction of frequency-building sessions, both children’s performances jumped up dramatically suggesting that frequency-building procedures were associated with, and controlled, high rate responding and positive celerations across all measures. For example, Neil’s tally slash writing climbed immediately back up to 300 per minute. Even on alphabet writing measures Chris’ rate suddenly jumped from 5(0) on day 83, to 11(3) on day 88.
Figure 3.3. The number of corrects per minute made by Chris in frequency-building and application probes over the 160 days of the experiment. The black circles represent the rate of correct tally slashes; the white circles represent the rate of correct o-loops; and the black squares represent the number of correctly formed upper case letters.
Figure 3.4. The number of corrects per minute made by Neil in frequency-building and application probes over the 187 days of the experiment. The black circles represent the rate of correct tally slashes; the white circles represent the rate of correct o-loops; the black squares represent the number of correctly formed upper case letters; and the white squares represent the number of correctly formed lower case letters.
During the following 50 days some very fast tally slash and o-loop rates were recorded and some very large gains in alphabet writing speed were achieved. Chris’ tally slash writing rate showed x1.2 celeration, more than doubling from a low of 228 per minute to a high of 480 per minute in 6 weeks, however his o-loop rate remained relatively unchanged, staying near 150(0) during this time. The results for uppercase writing doubled in rate going from 11 to 22 per minute (celeration of x1.2). Neil’s performance showed some remarkable changes during this phase with his tally slash writing rate showing x1.1 celeration climbing from 300 to 558 per minute. He also reached a o-loop writing rate of 282 on day 124, and continued to perform around the 250 per minute mark. Large jumps can clearly be seen at day 128 (from 378 to 420 per minute) and at day 135 (from 462 to 540 per minute). Examples of Chris and Neil’s writing taken from this time can be seen in Figures 3.5 and 3.6. During this phase the rate of alphabet writing probes also strongly covaried with the rate of tally slash writing for both children. A second return to baseline phase was then introduced and, unlike the previous baseline phase, both children’s performances remained stable.

After a 3 week non-teaching break, 2 more weeks of baseline were completed. Except for Chris’ o-loop writing, that reached a rate of 156 but dropped by about half after the break, all other rates for both children maintained at levels similar to those achieved before the break. Both children’s parents informed the trainer although the children had not been directly instructed in letter writing during the break, both had been practicing writing without prompting. Both were observed to write and copy letters on a daily basis by copying words from books and writing the alphabet.
Figure 3.5. Examples of Chris’ alphabet writing from Experiment 3.
Figure 3.6. Examples of Neil’s handwriting from Experiment 3.

Note. The top sheet is from day 100, the middle sheet from day 121, and the bottom sheet is from day 130.
Discussion

The results showed that freehand tally slash and o-loop writing skills taught to young children with autism responds to frequency-building procedures in ways consistent with previous successful applications of fluency-based training. Both children showed that freehand o-loop and tally slash writing increased under frequency-building conditions and, apart from Chris’ o-loop writing, rates were maintained after a significant period of non-practice. Interestingly Chris’ o-loop writing rate was the only skill that failed to achieve or get close to the frequency aims suggested by Freeman and Haughton (1993b). This result supports the conclusion that frequency aims gathered from studies of nonautistic populations can be used to set frequency aims for young children with autism when free-writing tally slashes and o-loops. Data from the application probes showed that changes in the rate of letter writing improved over time as the as the rate of tally slashes and o-loops increased under frequency-building conditions. Furthermore, at follow-up caregiver’s reported that Chris and Neil were now writing across a number of settings and situations. These results also provide support to Graham’s (1999) conclusion that fluent tally slash and o-loop writing skills may promote handwriting skills and provide evidence for the generality of frequency aims across populations.

The data also showed some interesting covariations between the rate of tally slash and o-loop writing and the rate of freehand alphabet writing at different times. The clearest example of this occurred for Neil between days 20 and 80
between o-loop writing and uppercase alphabet writing. The presence of these covariations suggests that there was a component-composite relationship between the skills practiced during frequency-building and letter writing. Similarly, for Neil, a drop and rise in his tally slash writing occurred at the same time as a drop and rise in his alphabet writing rate at the time of the frequency-building and baseline reversal between days 80 and 100. Given that the only systematic change was the treatment reversal, the data strongly suggests that, within the specifications of the current experiment, the rates of alphabet writing and tally slash and o-loop writing depended upon frequency-building. However, by the time the second return to baseline phase was introduced there was no noticeable change. This observation is consistent with a skill that has reached fluency and is consistent with descriptions of behavioural retention, endurance and stability.

Frequency-building conditions were always presented immediately before each application probe. This arrangement suggests that dense reinforcement and high response rates obtained under frequency-building conditions could have influenced the rate of responding during application probes. Similarly, behavioural momentum research would also predict that the children’s alphabet writing rates would drop once the preceding high-probability, highly-reinforcing condition was removed (Mace et al., 1997). However, the clear breaks between frequency-building and application probes make behavioural momentum an unlikely influence. A more likely effect would be the partial reinforcement delivered during frequency-building resulted in a behaviour that became increasingly resistance to extinction and stable. This is highly likely given that
the behaviour was even more resistant to extinction at the second return to baseline phase. Therefore the stability of both alphabet writing and tally slash and o-loop writing most likely depended upon the reinforcement delivered during frequency-building intervals. However, the strength of these conclusions would be improved with the inclusion of a control condition.

The next two experiments will further examine the influence that practicing component skills to fluency has on the composite skill performance for young children with autism. In the next two experiments the order in which application probes and frequency-building conditions are presented will be alternated and separated by a few hours.
EXPERIMENT 4: USING FREQUENCY-BUILDING TO TEACH CHILDREN WITH AUTISM TO SEE-SAY SINGLE-DIGIT ADDITION SUMS WHILST PROBING FOR APPLICATIONS TO ADDITION AND SUBTRACTION PROBLEMS

Introduction

The results from Experiments 2 and 3 showed that basic, component writing skills can be practiced to fluency and that this practice can result in gains on more complex, composite skills. The main aim of this experiment is to determine if simple addition facts taught to young children with autism would respond to frequency-building procedures in ways consistent with previous successful applications of fluency-based training. A second aim is to determine if this practice affects the performance of untaught additions sums and subtraction problems. Also, the design used in this experiment will separate application probes and frequency-building procedures by time and alternate the order in which they are presented across days.

Mercer and Mercer (1993) suggested that most math problems emerge because basic math facts: (1) lack sufficient practice, (2) have been incorrectly learned or, (3) have been missed altogether. Binder (1996), Johnson and Layng (1992; 1994), and Silbert et al. (1981) have also suggested that basic math facts need to be mastered before learners can move onto more complex skills. Children who
fail to learn these basic skills then face repeated failure as the curriculum leaves them behind. Furthermore, they face practical problems every day that extend beyond academic failure. For these children, math problems can also result in general school refusal problems, and restricted life opportunities (Mercer and Mercer, 1993). Some of the most basic daily living skills require an understanding of math, such as time planning, shopping, and managing finances. Therefore, math skills certainly form a potential behavioural cusp for the young learner.

Perhaps in no other academic area does mastery depend on both speed and accuracy of mathematics performance (Rhymer et al., 1999). Fortunately there has been a lot of work done on the effects of improving the response rate and accuracy of learner’s academic skills (Belfiore et al., 1997; Rhymer et al., 1999; Skinner, 1998; Van Houten et al., 1975; Van Houten & Little, 1982; Van Houten et al., 1974). One study by Van Houten and Thompson (1976) found that maths rates increased under explicit timing/response reinforcement contingencies. During baseline assessments learners were asked to complete as many problems as they could. During intervention learners were told that they had half an hour to complete as many math problems as they could, plus they were asked to underline the last problem they completed at each one-minute interval. The results clearly showed large increases in the rate of responding under intervention conditions.

Silbert et al. (1981) suggested that single-digit addition sums of values less than 5 form the first step in the hierarchy of addition skills. For this reason they will
be selected as the base component skill that will be taught under frequency-building procedures. Following on from the previous experiments, application probes will be taken of untrained addition sums (additions sums of values between 6 and 10 [Silbert et al, 1981]). Silbert et al. (1981) also suggested that subtraction skills generally do not benefit by having fluent addition skills, particularly without further instruction regarding the concept or meaning of the subtraction symbol. Therefore, application probes will be taken of simple subtraction problems. It is expected that without any direct instruction that the children’s performances would not change as a result of any practice on simple addition sums. Therefore, if the children’s rates improve across the subtraction sums then it is likely to be due to extraneous influences happening outside of the experimental procedures.
Selection Criteria and Participants

John and Terry were selected from the same pool as previous studies except they had emerging numeracy skills in the addition and subtraction of single digit numbers.

John

John was a 5-year-old boy with autism whose expressive language was sometimes echolalic and dissociative, but he was also capable of some functional language. In an independent assessment John obtained a full-scale IQ of 59 on the Wechsler Pre-school and Primary Scale of Intelligence – Revised (WPPSI-R), however he had also displayed “off-task” behaviour during this assessment making the validity of the results somewhat questionable. John had been receiving approximately 6 hours per week of home-based ABA intervention for about 12 months. From this intervention he learnt to match written numbers to a quantity of objects up to a value of 10. He was also able to say the answers to simple additions and subtraction sums (for numbers equal to or less than 4) when presented with the problems in written numerical format.
Terry was a 4½-year-old boy, diagnosed with autism. Terry, like John, displayed very few social and verbal skills, however, he had learnt to imitate well. An independent psychometric assessment, using the WPPSI-R and the Leiter International Performance Scale, had placed him in the borderline range for intelligence. His fine motor skills, like many of the children in the current study, were clumsy. He had received approximately 15 months of home-based applied behaviour analysis discrete-trial intervention, at about 8 hours per week where he had learned to match written numbers to quantities of objects up to a value of 10. He was also able to say the answers to simple additions and subtraction sums (for numbers equal to or less than 4) when presented with the problems in written numerical format.

**Setting and Materials**

The sessions were conducted in the children’s home in a setting similar to that described in experiment 3. Materials included in this experiment were 3 specially designed work sheets. The first, the addition (0 to 5) work sheet, was printed on 29.5 cm x 21 cm paper and contained 25 different addition problems written in numerical format, typed in 12 point Times New Roman font. These problems were of sums between 0 and 5 and were arranged in 5 rows of 5,
approximately 3 cm apart from one another. These were used in the frequency-building condition.

The second and third work sheets were formatted in the same way except one contained 25 additions of sums between 6 and 10, and the other had 25 subtraction problems of values no greater than 10. Both of these worksheets were used in the application probes.

60 versions of each work sheet were generated, with each containing a different arrangement of the 25 problems.

**Target Behaviour and Response Definitions**

The target behaviour was say the correct answer to the first problem and move on to next problem. The child’s answer was scored correct if it was recognised by the teacher as the correct answer to the problem he was looking at. Any other verbal response was scored as an error. An error was also scored if the child skipped a problem.
Data Collection and Interobserver Agreement

The numbers of corrects and the numbers of errors made per interval were collected and charted using the same procedures as those used in experiment 2. All of the sessions were checked for interobserver agreement using the same video scoring procedures that were used in experiment 1. Percentages of data that was checked for reliability are presented in Table 4.1.

Experimental Design

The effects of frequency-building on the target behaviour were assessed using an ABABA design with long term follow up. Application probes were taken approximately 3 times a week on the addition (6 to 10) and subtraction work sheets. On those days, the order of instruction was alternated with either the application probe being administered in the morning (between 9 and 11 am) and the frequency building completed in the afternoon (between 3 and 5 pm), or vice versa. The design is illustrated in the following flow chart. A frequency-aim between 80 and 100 per minute was selected as the fluency aim because this was the rate at which an adult could complete the task.

<table>
<thead>
<tr>
<th>Baseline</th>
<th>Frequency Building</th>
<th>Baseline</th>
<th>Frequency Building</th>
<th>Baseline</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Application Probes</td>
<td></td>
<td></td>
<td></td>
<td>Application Probes</td>
</tr>
</tbody>
</table>

Table 4.1

The Percentage of Data Checked for Reliability in Experiment 4

<table>
<thead>
<tr>
<th>Phase</th>
<th>Child</th>
<th>Baseline</th>
<th>Frequency Building</th>
<th>Application Probes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Neil</td>
<td>45%</td>
<td>37%</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>Chris</td>
<td>43%</td>
<td>40%</td>
<td>33%</td>
</tr>
</tbody>
</table>
Procedure

Baseline

The procedures used here were nearly identical to the procedures used during baseline in experiment 2, with the only difference being the teacher told the child to “Do the sums in order” on the addition (0 to 5) work sheet. Two, 60-s interval were completed at each session and a different work sheet was selected from the pool of 60 work sheets each time.

Application Probes

The procedures used here were the same as used during baseline except the intervals were 30-s long and the child was required to “Do the sums in order” on the addition (6 to 10) and subtraction work sheets.

Frequency-building

The frequency-building procedures used here were similar to those in experiment 2. The child was required to say the answers as fast as he could. If he hesitated
for more than 2 seconds the teacher stated the correct response. Intervals were repeated until the total time for each session added up to 120-s. The sessions with John contained either four, 30-s intervals; six, 20-s intervals; eight, 15-s intervals; or twelve, 10-s intervals. Terry was kept on 30-s frequency-building intervals for the duration of the experiment. The worksheets were changed for each interval, rotating through all 60 worksheets. The rate of token delivery ranged from every fourth response to every sixth response; with an average rate of 4.76 correct responses per token delivery. Once the child had accumulated 15 tokens he was given access to the reward tray at the following break.

Results

The results are presented in Figures 4.1 and 4.2 for John and Terry respectively (the raw data are presented in appendices L through M). The first session began with an application probe in the morning and frequency-building session in the afternoon. During baseline the children’s rates were slow, scoring less than 7 per minute across all measures.

30-s frequency-building sessions were then introduced and both children’s rates on the target behaviour increased. John’s rate climbed from a low of 6(4) to a high of 26(0) by day 39. He was then tried under 15-s intervals and his rate climbed at an even faster rate, going from 24(0) to 36(0) in 5 sessions. Terry’s performance similarly improved under frequency-building conditions, with his
rate climbing from 12(4) to a high of 28(0) by day 33. Data taken from the application probes showed that both children’s performances on addition facts also improved over this time. Both children’s data, John most clearly, showed a clear co-variation between the rate of the target behaviour and the rate of the addition facts in the probe condition and John performed with no errors from this point on. Both children’s performances on the subtraction facts remained unchanged from baseline levels.

Baseline conditions were then reintroduced for 14 days and both children’s target behaviour rates decreased slightly. John’s rate fell from 26(0) to 19(0) and Terry’s from 23(0) to 18(0). However, these rates were still more than 4 times faster than both of their performances from the first baseline phase. Data taken from the addition facts application probes also showed a decrease in rate for both children. These data are consistent with observations from the previous two experiments and show that the rate of performance on the addition sums (0 to 5) and addition sums (6 to 10) depended upon the presence of frequency-building conditions. In extending the previous findings, the data are consistent with the predictions of Silbert et al. (1981) and show that neither child’s performance on the subtraction sums was influenced by frequency-building addition sums (0 to 5).

With the reintroduction of frequency-building conditions, both children’s rates increased. John’s rate climbed from 28(0) to 44(0) in just over two weeks. This marked a considerable improvement from baseline levels and approached the fluency aim of 80 per minute. He was then taught for nearly 4 weeks using 10-s
intervals, which resulted in only a modest gain, with his rate peaking at 66(0).
The pattern of his data, taken during this time, showed a levelling out rather than a steep, acceleration slope. 20-s intervals were then tried, and during the third week of this phase his rate began to increase again, jumping from 75(0) to 96(0) in 4 days. This phase was then followed by one week of 30-s intervals and his rate levelled out at around 92(0) per minute. During this time John’s performance on the application probes had also changed. His additions facts continued to improve in proportion to his improvements on the target behaviour, hitting a high of 36(0) correct per minute. His performance on the subtraction facts also changed, however this rate decreased rather than increased. At day 140, his response rate had slowed down to a consistent 2 errors per minute (near the end of the second frequency-building phase). By this time John would only attempt 2 problems, stop what he was doing and begin drawing on the sheet of paper.

Although Terry practiced under 30-s intervals for the entire 9 weeks during the second phase of frequency-building, his data described a pattern almost identical to John’s. His rate accelerated quickly during the first 21 days, levelled off for the next 12 days, before accelerating again and peaking at 106(0). His performance on the addition facts application probes showed proportional gains with a concurrent decrease in his response rate on the subtraction facts. Two large jumps in his addition facts (application probe) rate were observed around the same time that his target behaviour jumped from 54(0) to 84(0), and from 80(0) to 106(0) per minute. At those times his rate increased from 26(0) to 34(0), and from 38(0) to 72(0), respectively. Baseline conditions were then
introduced and both children’s performance rates maintained then and after a
break of 28 days. John’s error rate on the subtraction facts application probe
increased to 0(6). An analysis of the data based on order revealed no
discernable patterns related to the order of presentation, with no advantage for
either morning or afternoon frequency-building sessions.
Figure 4.1. The number of corrects and errors per minute made by John over the 187 days of the experiment. The white squares represent the rate of correct responses made; and the black squares represent the number of error responses made.
Figure 4.2. The number of corrects and errors per minute made by Terry over the 152 days of the experiment. The white squares represent the rate of correct responses made; and the black squares represent the number of error responses made.
Discussion

The results of this experiment showed: (1) frequency-building conditions were associated with increasing rates over time, (2) the see-say rate of addition sums (6 to 10) in the application probes also increased over time, but only when the target behaviour was concurrently under frequency-building conditions, and (3) the rates achieved by the end of frequency-building were maintained after a significant period without practice. This experiment also extends the findings and conclusions of the previous experiments in two ways. Firstly, at baseline both children had very poor addition (values 6 to 10) and subtraction skills, scoring only 1 or 2 correct per minute. Over the duration of the experiment the rate and accuracy of the children’s performances on the subtraction problems slightly diminished over time, whereas addition problems improved exponentially. Secondly, the order of the training did not appear to affect the results. As a result of the design modifications employed in this experiment, it seemed that the change observed on the speed and accuracy of the additions sum (5 to 0) and the addition sums (6 to 10) could only be accounted for by the frequency-building conditions.

However, experimental control can be improved further. Even though using 60 variants of the practice sheets minimised the likelihood of the children learning a particular sequence by rote, this design didn’t control for learning during the probes. One way to do so would be to reduce the amount of exposure the children have to probe items.
The next experiment will continue with the aims of the current experiment, but will examine the influence training component reading skills to fluency have on composite reading performance for young children with autism. In the next experiment several more control conditions will be used to provide more robust evidence for skill application.
EXPERIMENT 5: USING FREQUENCY-BUILDING TO TEACH CHILDREN WITH AUTISM TO SEE-SAY SINGLE PHONEMES WHILST PROBING THE SEE-SAY RATE OF 3-PHONEME WORDS

Introduction

The previous experiments showed that motor imitation, basic writing skills (tracing and freehand), and simple addition facts could all be taught to young children with autism so that retention, endurance, and stability were achieved. Furthermore, all showed application to other skills taught without any extra instruction or training. The main aim of this experiment is to determine if single phonemes read aloud by young children with autism will respond to frequency-building procedures in ways consistent with previous successful applications of fluency-based training. Secondly, this experiment aims to determine if the frequency-aims gathered from studies of nonautistic populations can be used to set frequency-aims for young children with autism. Thirdly, this experiment aims to determine the effect frequency-building phonemes has on the performance of reading words containing the practiced phonemes and words containing unfamiliar phonemes. Johnson and Layng (1994; 1996) suggested that only skills with fluent elements should recombine and adduce. Therefore, it is expected that adductions should only occur with words containing familiar phonemes. To provide better control for potential practice effects during the application probes, a set of problems will only be administered twice - briefly as
a pre-test and once again as a post-test. Maloney (1998) suggested a frequency aim for see-say sounds in isolation based on sampled rates from nonautistic populations. This aim was to see-say sounds at a rate between 60 and 80 per minute.

A secondary purpose, pointing at the letters with a plastic straw will be compared to pointing at the letters with a finger during frequency-building. Lindsley (1996) suggested that this modification could substantially increase a learner’s rate of performance and, therefore, result in a lot more practice per unit of time. Given that practice is vital for developing fluency (Binder, 1996), any gains in the amount of practice may prove valuable.

**Research On Reading**

Becker (1977) and Englemann (1992) suggested that most elemental skill a child will need for reading is saying the sounds that each letter represents – not the letter name. For example, when a learner sees the printed letter “m”, it is more important and valuable for the learner to say the sound “mmm” rather than pronounce the name “em”. An enormous amount of research effort has gone into evaluating the best instructional sequences for teaching reading. Two major reviews, Anderson, Hiebert, Scott and Wilkinson (1985) and Adams (1988), concluded that instruction that ensured good letter-sound correspondence produced better readers than any other method. Pflaum et al. (1980) and Downs
and Morin (1990) arrived at similar conclusions after observing that children who had mastered phonemes decoded text more effectively than other children.

Bosch and Fuqua (2001) observed that learning phonemes to fluency has “…great generative potential because their recombination will allow reading without having to learn each word…” (p. 124). Findings by Adams and Englemann (1996), Becker (1977) and Daly, Martens, Hamler, Dool and Eckert (1999) support these claims by, firstly, demonstrating that learners who have mastered saying letter sounds (see printed letter-say phoneme) perform better during word reading than those children who have not yet mastered this skill and, secondly, with each new phoneme mastered the learner could then decode an increasing number of words. Distar programs exploit the generative nature of phonemes and teach letter sounds systematically based on the frequency of use within the English language (Becker, 1977; Binder & Watkins, 1990; Watkins, 1997). The first 6 letter sounds (m, s, a, t, e, d) of the Distar sequence will be used in this experiment.

Precision Teachers have also identified that the saying sounds is a component skill to reading – however they have also identified frequency aims that help teachers ensure that fluency has been achieved (Spence & Hively, 1993). Haughton (1971; 1972) and Freeman and Haughton (1993a) identified that a prerequisite to effective oral reading is for a learner to say sounds at frequency of about 100 per minute or more. In their study learners who performed much below this level later experienced long-term difficulties when reading. Maloney
(1998) also observed that being able to say sounds in isolation at rate above 80 per minute predicted retention, endurance, and improved reading performance.

Method

Selection Criteria and Participants

The criteria used to select the participants for this experiment were the same as those used in the previous experiments. The two children who participated were Justin (who participated in Experiment 2) and Tim. They had been taught to point with their right hand, using their finger or a pointer (a 15-cm plastic straw), at letters and say the sound. However, neither had been taught to blend phonemes together to read a word. Both understood the commands “say the sounds” and “say the words” and “point” and “point with your finger”. During independent assessments both children pointed to the numerals 1 to 20, said some phonemes (m, s, a, t, e, d), and labelled objects in pictures on request (hear-point). However, they had not mastered these skills and were slow and inaccurate.
Tim

Tim was a 4 year and 8 month old boy, diagnosed with autism, whose aggressive and disruptive behaviours included hitting, kicking and throwing objects. He lacked interpersonal and social communication skills and displayed some bizarre vocalisations and would either shout or whisper when talking. He gave infrequent eye contact when spoken to, or looked at, and he did not imitate any motor movements. Tim had received approximately 6 hours per week of home-based ABA intervention for about 6 months.

Setting and Materials

The setting at each child’s home was the same as the setting in experiment 3. Materials included for this experiment were a 15 cm plastic straw and specially designed work sheets for phoneme and word reading. The phoneme work sheets were printed on 29.5 cm x 21 cm sheets of paper, each containing 36 letters typed in 12 point Times New Roman font. The letters were arranged in 6 rows of 6, approximately 3 cm apart from one another. The 6 letters (“m”, “s”, “t”, “e”, “a”, “d”) each appeared 6 times and in no particular order. 30 different versions of how the letters were ordered were generated for this experiment.

4 sets of word work sheets were arranged in the same way. Each word work sheet contained 6 words listed in a single column, approximately 3 cm apart. The 4 sets are presented in Table 5.1. Set 1 consisted of two letter combinations
of the sounds presented under frequency-building conditions. Sets 2 and 3 were equivalent forms of each other and consisted of three-letter word combinations of the sounds presented on the phoneme work sheets. Set 4 consisted of three phoneme combinations, which consisted of none of the sounds included on the phoneme work sheet. 18 versions of each set were generated.
Table 5.1

The Items From the Application Probes in Experiment 5

<table>
<thead>
<tr>
<th>Name</th>
<th>N</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set 1</td>
<td>6</td>
<td>me, et, se, ma, da, ta.</td>
</tr>
<tr>
<td>Set 2</td>
<td>6</td>
<td>met, sed, mat, ads, ats, sad.</td>
</tr>
<tr>
<td>Set 3</td>
<td>6</td>
<td>mad, set, mes, dam, sam, det.</td>
</tr>
<tr>
<td>Set 4</td>
<td>6</td>
<td>pig, nip, fun, lip, hug, nib.</td>
</tr>
</tbody>
</table>
Target Behaviour and Response Definitions

A child’s attempt had to finish before the end of the interval to be counted. The target behaviour was the child reading out the phoneme he was pointing at on the work sheet. An attempt was scored correct if the sound was recognised by the teacher as the letter that the boy was pointing at.

When reading from the word work sheets the phonemes contained in each word had to be blended (i.e. said as a single syllable) in the same sequence as written. If a child did not attempt to read the sound or word within 3-s seconds of pointing at it, or skipped a phoneme or a word, then an error was scored. Based on Haughton and Freeman (1993a) a frequency aim of 80 to 100 per minute was set for reading phonemes.

Data Collection and Interobserver Agreement

The two dependent variables, the number of corrects and the number of errors made per interval, was collected and charted using the same procedures as Experiment 2.

Interobserver agreement checks were achieved using the same procedures as those used in experiment 1. The percentages of agreement checks completed across both children over the phases of this experiment are presented in Table 5.2.
Table 5.2

The Percentage of Data Checked for Reliability in Experiment 5

<table>
<thead>
<tr>
<th>Phase</th>
<th>Child</th>
<th>Baseline</th>
<th>Frequency Building</th>
<th>Application Probes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tim</td>
<td>33%</td>
<td>48%</td>
<td>46%</td>
</tr>
<tr>
<td></td>
<td>Justin</td>
<td>33%</td>
<td>52%</td>
<td>53%</td>
</tr>
</tbody>
</table>
Experimental Design

The effects of frequency-building procedures on both children’s see-say phoneme rate were assessed using an ABABA design, with long-term follow-up. Application probes for reading, using Sets 1, 2 and 4, were administered across sets of words when either: (a) the target behaviour’s rate changed dramatically, or (b) the intervals were reduced or increased in the frequency building sessions. Set 3 was presented twice – in baseline and follow up. On those days when probes were taken the order of presentation was alternated with the application probe being administered in the morning (between 9 and 11 am) and the frequency building completed in the afternoon (between 3 and 5 pm), or vice versa. An application probe was taken for 3 successive sessions to control for unusually poor or superior performances affecting the data. Justin used the plastic straw, to point at the printed letters on the phoneme work sheets however, Tim alternated between using the straw and pointing at the printed letters with his finger. During the application probes both children only used their fingers. Sets 1, 2, and 4 were assessed every time application probes were conducted. Set 3, an equivalent form to 2, was only presented twice. The design for this experiment is illustrated in the following flow chart.

<table>
<thead>
<tr>
<th>Baseline</th>
<th>Frequency Building</th>
<th>Baseline</th>
<th>Frequency Building</th>
<th>Baseline</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Application Probes</td>
<td></td>
<td>Application Probes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Procedure

Baseline

A phoneme work sheet was placed in front of the boy and the teacher prompted the boy to either point with the straw or with his finger at the work sheet. The teacher then said, “Point and say the sounds” and started the timer running down from 60-s. At the end of the interval the teacher selected a new work sheet and completed another 60-s interval. Otherwise the procedures were identical to the baseline procedures used in the previous experiments. Baseline was continued for a minimum of 3 sessions until a reliable pattern of responding was established.

Application Probes

The teacher set the timer to 20-s, arranged the setting, and sat facing the boy at the table. A word work sheet was placed on the table. The teacher held up his finger and said, “Point and say the words” and started the timer counting down. When the boy attempted one of the words, the word was covered up so that the child did not re-read the same word over and over again. If all 6 had been attempted then the list was uncovered and the procedure repeated until the
interval finished. At the end of the first interval 1 token was delivered and a new work sheet from the same set was placed in front of the child. Two more 20-s tests were administered using the same procedure, except 2 tokens were delivered at the end of each test. Sets 2, 3, and 4 were tested in the same way. Any other procedures were the same as those used at baseline. Each probe was run for 3 successive sessions.

**Frequency-building**

The procedures used for frequency-building were almost identical to the frequency-building procedures used in Experiment 2 with the only difference being the task required the child to “Point and say the sounds”. At each session, intervals were repeated until the total time frequency-building added up to 120-s. The rate of token delivery ranged from every third response to every sixth response; with an average rate of 4.11 correct responses per token delivery. Once the child had accumulated 15 tokens he was given access to the reward tray at the following break.
Results

The results are presented in Figures 5.1 and 5.2 and Tables 5.3 and 5.4 for Tim and Justin respectively (the raw data are presented in appendices N through O). During baseline both children performed slowly but accurately when saying phonemes, varying between 12(0) and 18(0). 10-s frequency-building intervals were then introduced, with both children accelerating quickly to higher rates, although their data show quite different performance patterns in getting there. Tim’s rate increased from 42(12) to 84(0) from day 19 to day 41 in a fairly constant celeration of x1.3. Justin’s rate climbed from 24(0) to 66(0) from day 18 to day 45, though in getting to that rate his data show the first 3 weeks were quite error full and erratic, whereas the final 2 weeks show quite a steep celeration of x1.6. Both children showed small improvements on Set 1 at the second application probe. They were unable to sound out any of the words in Sets 2 and 4. Set 3 was not administered at this time.

Baseline conditions were then reintroduced because both children had reached the frequency aim of 80 per minute. However, given that this rate had only been achieved with 10-s sprints, the 60-s timings also provided good endurance probe assessments. Both children’s rates decreased when compared to those achieved under 10-s frequency-building conditions, with Justin’s rate returning to levels similar to those achieved at the first baseline phase. Tim’s rate was higher than his initial baseline levels, but still fell to around 50(0) per minute. Clearly neither child had achieved endurance or stability. Frequency-building conditions
were then reintroduced with Tim’s rate immediately returning to 100 correct per minute. Justin’s rate also accelerated quickly and within 6 sessions had returned to 70 per minute.

A third application probe revealed small improvements for Tim and Justin across Sets 1 and 2 (median scores of 6[3], 3[6] and 12[0], 3[0] respectively) and a rate of 0 for Set 4.

For the next 7 sessions Tim was taught with 40-s and then 60-s intervals for the purpose of probing for and teaching skill endurance. His rate maintained near 100 per minute during this time. Justin’s rate also regained previous highs with the reintroduction of frequency-building and peaked above 80 per minute. Baseline was then reinstated and both children’s rates were a lot higher than at the previous baseline assessment. Both Tim and Justin achieved 80(0), a score some 6 times faster than their rates during the first baseline phase. A fourth application probe administered and Tim showed improvements on Sets 1 and 2 (9[3] and 6[0] respectively). Justin similarly scored 12(0) and 6(0) on Sets 1 and 2 respectively. Both children failed to get any of the items on Set 4 correct and Set 3 was not administered at this time.

Following a one-month break both children were able to retain the rates they had achieved. A fifth application probe revealed that both children had retained or improved their rates on Sets 1 and 2. Most importantly both children also achieved rates between 6(0) and 9(0) on Set 3 that was last administered at baseline and had not been tried for 130 days. Justin’s results across the
application probes mirror Tim’s performance almost identically. Across the entire experiment, changes were observed across Sets 1, 2 and 3, with no change on Set 4.

Incidentally, throughout the experiment Tim clearly demonstrated that he could perform faster when using the straw at all times. Generally straw pointing allowed him to perform 20 to 30 counts per minute faster than with finger pointing alone.
Figure 5.1. The number of corrects and errors per minute made by Tim over the 133 days of the experiment. The symbol (F) indicates pointing with the right index finger; the symbol (P) indicates using the straw pointer to point at the letters on the work sheet.
Table 5.3

The Median Rate and Range Obtained by Tim Over the 5 Application Probes in Experiment 5

<table>
<thead>
<tr>
<th>Sets</th>
<th>Probe 1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set 1</td>
<td>Mdn</td>
<td>0</td>
<td>3(3)</td>
<td>6(3)</td>
<td>9(3)</td>
</tr>
<tr>
<td></td>
<td>Range (correct)</td>
<td>3–6</td>
<td>6-9</td>
<td>9-12</td>
<td>9-12</td>
</tr>
<tr>
<td>Set 2</td>
<td>Mdn</td>
<td>0</td>
<td>0</td>
<td>3(6)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Range (correct)</td>
<td></td>
<td></td>
<td>6-9</td>
<td></td>
</tr>
<tr>
<td>Set 3</td>
<td>Mdn</td>
<td>0</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Range (correct)</td>
<td></td>
<td>6-9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set 4</td>
<td>Mdn</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Range (correct)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Range values left blank indicate that the median value was scored on every attempt.

The values in parentheses are the **errors per minute** score obtained with the median rate **corrects per minute**.

a
Figure 5.2. The number of corrects and errors per minute made by Justin over the 130 days of the experiment.
Table 5.4

The Median Rate and Ranges Obtained by Justin Over The 5 Application Probes in Experiment 5

<table>
<thead>
<tr>
<th>Sets</th>
<th>Probe</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Set 1</td>
<td>Mdn</td>
<td>0</td>
<td>6(3)</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Range (correct)</td>
<td></td>
<td>6–9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set 2</td>
<td>Mdn</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Range (correct)</td>
<td></td>
<td>6-9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set 3</td>
<td>Mdn</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Range (correct)</td>
<td></td>
<td>6-9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Range values left blank indicate that the median value was scored on every attempt.
Discussion

The results demonstrated that single phonemes read aloud by young children with autism responded to frequency-building procedures in ways consistent with previous successful applications of fluency-based training. Specifically, the data showed that frequency-building conditions were associated with increasing correct response rates and that, following frequency-building, the rate of correct responding retained after a significant period without practice. The results further showed that this practice improved the performance of reading words containing the practiced phonemes only. Consistent with earlier predictions, words containing unfamiliar phonemes failed to show any improvement. Furthermore, the results supports the conclusion that frequency aims gathered from studies of nonautistic populations can be used to set frequency aims for young children with autism when see-saying sounds in isolation.

By examining the data more closely, the first return to baseline phase resulted in a dramatic drop in the response rate of both children. This observation suggests that at the time the rate of the target behaviour was controlled by the frequency-building conditions. From a behavioural fluency perspective, endurance and retention had not been achieved. However, with more sessions of frequency-building, a return to baseline failed to affect response speed and accuracy. From an experimental perspective, control had been lost. However, from a behavioural fluency perspective, and an educational one, the children’s response rate now demonstrated endurance and retention (resistance to extinction) over the two
weeks of baseline. It should be noted that endurance was achieved without an increase in rate during frequency building in Tim’s case suggesting that overtraining is important. It also clearly shows that 60 per minute over 10-s is not the same at 60 per minute over 60-s.

The data also demonstrated that exposure alone was not sufficient to improve phoneme reading for those phonemes not taught under frequency-building conditions. This finding supported the data gathered in Experiment 4 when frequency-building was restricted to addition problems, the children failed to show improvements on subtraction problems. However, in experiment 4, it was suggested that the rates achieved on the addition probes may have been inflated because the large amount of probes taken could have allowed the children to practice the items. The data gathered from this experiment, however, showed that there was little difference in the rate of performance between Set 2 and Set 3 (similar sets of items), despite Set 2 being presented twice as often as Set 3. This finding supports the component-composite relationship between the target behaviour and the words used, and suggests that the strength of relationship was demonstrated by the change on Sets 2 and 3 in the application probes.

This experiment also provided an investigation into the use of ergonomic modifications that may aid, or increase, the rate of response. In agreement with Lindsley (1996), Tim’s data clearly show that higher rates were achieved when pointing with the straw. Over the course of the experiment, and regardless of order of presentation, Tim performed at a higher rate when pointing with the straw. However, just because he was able to perform the task more quickly does
not necessarily mean he achieved fluency quicker because of this modification. Whether or not this is the case remains a topic for future investigations.

However, the importance of speed of response during practice will be examined in Experiment 6. Experiment 6 will compare the effects of overlearning (trials focused, without the free-responding associated with frequency building) to frequency building when teaching children to see-say general knowledge questions on flashcards.
EXPERIMENT 6: COMPARING SELF-PACED PRACTICE WITH TIME-CONTROLLED TRAINING WHILST CONTROLLING FOR NUMBER OF TRIALS

Introduction

The first 5 studies showed fluency criteria could be achieved with young children with autism when practicing under self-paced, frequency-building procedures. However, could the same results have been achieved with slower paced time-controlled training if matched for practice? The main aim of this experiment was to determine if self-paced practice will result in greater gains than time-controlled training when teaching young children to answer general knowledge questions written on palm cards when matched for practice opportunities and reinforcement.

Dougherty and Johnston (1996) suggested that skill performance following self-paced and time-controlled training might be the same if matched for practice. The key differences between these procedures is how the skill is practiced (self-paced versus externally controlled), the dependent variable used to measure performance (frequency versus percentage correct), and the definition of when true mastery has been achieved (frequency aims versus number of extra trials past 100% accuracy).
Belfiore, Skinner and Ferkis (1995) showed that time-controlled practice resulted in more words mastered for all 3 participants than a self-paced, frequency-building condition. Similarly, Fiske, Hodge, Lee and Rogers (1990 cited in Bucklin et al., 2000) showed that the number of training trials (720, 2160, or 4320 trials) that 12 participants received positively predicted the retention of a verbal learning task at 30, 90 and 180-day follow-up probes. On the other hand, Naslund (1987) showed that participants who practiced a set of motor skills at their own pace showed better retention 1 week after training than a group who were given the same amount of practice, but to an accuracy criterion only. Further still, Oddsson (1998) compared free-responding to controlled responding procedures using a verbal learning task and found that his procedures resulted in near identical outcomes. However, it is important to note that he used a fluency criterion of 30 per minute, which falls well short of most estimates of skill fluency (Binder, 1996; Haughton, 1971). Although a variety of instructional strategies can improve learner performance, there have been no direct comparisons between free- and controlled-responding procedures, which control adequately for number of practice opportunities and reinforcement.

In this experiment self-paced instruction and time-controlled training will be matched for practice and reinforcement. Some of the learners will be required to reach an overlearning criterion, whereas others will need to meet a frequency aim. The chosen method for practice will be SAFMEDS palm cards because these can be easily practiced with either self-paced or time-controlled procedures.
Ogden Lindsley developed SAFMEDS in 1975 for his graduate classes at the University of Kansas (Lindsley, 1996c). SAFMEDS are Precision Teaching’s version of flashcards. SAFMEDS is the acronym for how the cards are practiced – “Say All Fast, a Minute Every Day, Shuffled”. The name was introduced to ensure that the cards would be practiced correctly (Lindsley, 1996). SAFMEDS are usually designed with a front and back, question and answer pair. For example, if “Which country is the world’s biggest island?” as written on the front of the SAFMEDS, “Australia” would be written on the back. However, math facts, colours and their names, and language translations can all be practiced using SAFMEDS. During practice, as each card is shown, the learner sees the front side of the card and responds by saying the “answer” on the back. If the learner cannot remember the answer they simply turn the card over, see the answer, and then move onto the next card (Graf, 1994). Like all Precision Teaching practice and assessment intervals, SAFMEDS are carefully timed and the speed of correct and incorrect responses is measured and charted. Similarly, timing intervals can be adjusted based on the learner’s performance. For example, if errors persist intervals can be reduced and then, as performance improves, gradually longer intervals can be tried (Graf, 1994). SAFMEDS are excellent for frequency-building and work best when building fluency on specific dichotomous, factual content (Graf, 1994; Maloney, 1998). They are most commonly practiced using the see-say learning channel.
Bolich and Sweeney (1996) and Calkin (1996) have used SAFMEDS to help learners acquire new languages and improve translation skills. In both of these studies a word or symbol from the new language (e.g. Hebrew, Russian) was written on the front, and the English translation was written on the back. In practice SAFMEDS are generally limited to 50 card decks, as this has been found to be about the most any “…individual can handle easily in a minute…” (Maloney, 1998 p.149). McDade and Olander (1990) also showed that learner held, self-paced SAFMEDS produced steeper celeration slopes than if somebody else presented the cards. Frequency aims for SAFMEDS are set at about 50 to 60 corrects per minutes with only 1 or 2 errors, although many students achieve much higher (Graf, 1994; McDade, Austin & Olander, 1985).

The current study will use general knowledge questions printed on flashcards (SAFMEDS format). Performance will be tested under self-paced conditions, in the presence of an audio stimulus, when the same questions are asked verbally (via the hear-say learning channel), and after breaks in training.
Method

Participants

3 boys (Evan, Roger, and Nick) and 2 girls (Sharon and Pat) who had just commenced the 6th grade at a local primary school were the participants in this experiment. They were all 10 years old, of average intelligence (based on an assessment on the WISC-III Wechsler, 1991) and had achieved age equivalent scores on the Neale Analysis of Reading Ability. Prior to commencement, they were asked 20 questions which they did not answer correctly (Table 6.1). Each child’s parents had given written informed consent for their child to participate.

Setting and Materials

The children were tested in their homes with a video camera positioned pointing over the trainer’s shoulder so that the back of the flash card the child was holding and the child’s face were in frame.

40 flash cards, 8 cm high by 5 cm wide, were constructed from white cardboard. Each card had a question printed on the front side and the answer printed on the back in Times New Roman font, size 12. 20 of the cards were “who?” questions;
the other 20 were “how many?” questions. Both sets of questions were redivided into two sets of 10 flash cards. These sets and their corresponding questions appear in Table 6.1. These questions were taken from the board game Trivial Pursuit.

Target Behaviour and Response Definitions

Two target behaviours were used in this experiment. The first was answering out loud the question written on the flashcard correctly, or read-say the flashcards. If the child said the answer to the question, without turning the card over and looking at the answer, then the response was scored correct. Anything else was scored as an error, including self-corrections. The second measured behaviour was correctly answering out loud a question read by the trainer, or hear-say the answers.

Roger and Sharon were assessed and taught using the two sets of 10 “how many?” flash cards, whereas Evan, Nick, and Pat used the two sets of 10 “who?” flash cards.
Table 6.1

The 4 Sets Of Questions Used in Experiment 6

<table>
<thead>
<tr>
<th>Set</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>&quot;Who?&quot; – set 1</td>
<td>Who wrote <em>Goodbye Columbus</em>? Philip Roth</td>
</tr>
<tr>
<td></td>
<td>Which folk singer died of</td>
</tr>
<tr>
<td></td>
<td>Huntington’s Chorea? Woody Guthrie</td>
</tr>
<tr>
<td></td>
<td>Who allegedly killed officer</td>
</tr>
<tr>
<td></td>
<td>J.D. Tippit? Lee Harvey Oswald</td>
</tr>
<tr>
<td></td>
<td>Who created the fictional Character Zooey? J.D. Salinger</td>
</tr>
<tr>
<td></td>
<td>Who is known as The Father Of Geometry? Euclid</td>
</tr>
<tr>
<td></td>
<td>Who headed the Gestapo? Heinrich</td>
</tr>
<tr>
<td>Himmler</td>
<td>Who founded the Australian Democratic Party? Don Chipp</td>
</tr>
<tr>
<td></td>
<td>Who was made the first honorary citizen of the USA? Winston</td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>What character did Jim Banks create in 1921?</td>
<td>Ginger</td>
</tr>
<tr>
<td>Who played George Smiley on TV?</td>
<td>Sir Alec</td>
</tr>
<tr>
<td>Who delivered fireside chats?</td>
<td>Franklin</td>
</tr>
<tr>
<td>What was Cinderella’s real name?</td>
<td>Ella</td>
</tr>
<tr>
<td>Who wrote Matters For Judgement?</td>
<td>Sir John Kerr</td>
</tr>
<tr>
<td>Who wrote The Red Badge of Courage?</td>
<td>Stephen</td>
</tr>
<tr>
<td>Who narrates the Sherlock Holmes stories?</td>
<td>Dr. Watson</td>
</tr>
<tr>
<td>Who won the 1982 archibald prize?</td>
<td>Eric Smith</td>
</tr>
<tr>
<td>What Australian premier published a cookbook?</td>
<td>Don Dunstan</td>
</tr>
</tbody>
</table>
Who was Lancelot’s son in Arthurian legend? Galahad
Who was Ben Casey’s boss? Dr. Zorba
Who wrote *Sexual Politics* and *Flying*? Kate Millett

<table>
<thead>
<tr>
<th>Set</th>
<th>Items</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>“How Many?” – set 1</td>
<td>How many holes of golf are normally played in the Australian Open? 72</td>
</tr>
<tr>
<td></td>
<td>How many squares are there on a chessboard? 64</td>
</tr>
<tr>
<td></td>
<td>How many astronauts manned each Apollo flight? 3</td>
</tr>
<tr>
<td></td>
<td>What’s the minimum number of</td>
</tr>
</tbody>
</table>
bars on an abacus | 9
---|---
How many Australian prime Ministers have died in office? | 3
What is considered the luckiest number worldwide? | 9
How many colours are there in a rainbow? | 7
How many holes in a standard horseshoe? | 8
How many times thicker is blood than water? | 6
How many steps in John Buchan’s novel? | 39

<table>
<thead>
<tr>
<th>Set</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
</tbody>
</table>

“How many?” – set 2
How many pawns does each player have at the start of a chess game? | 8
Data Collection and Interobserver Agreement

The two dependent measures used were the number of corrects and the number of errors made per interval, expressed as a count per minute. Unlike previous experiments, every interval was charted in this experiment. All of the data presented were checked, and agreed upon, using the same video scoring procedures as used in experiment 1.

Experimental Design

The effects of 2 teaching methods, self-paced and time-controlled training, were compared using an alternating treatments design, with baseline and follow-up assessments. Roger and Sharon were taught the 20 “how many?” questions, whereas Nick, Evan and Pat were taught the 20 “who?” questions. 10 questions were taught via self-paced training procedures, whereas the other 10 were taught with time-controlled training procedures. Nick’s overlearning trials were completed at half the pace of the others. The number of flash cards presented between time-controlled training and self-paced training intervals was yoked so that both treatments had an equal number of questions presented (learning opportunities) over the course of the experiment. Probes were also taken of the children’s hear-say rate, and of each child’s see-say rate with the radio turned on. Baseline, treatments, and return to baseline were all conducted on a single day.
Follow-ups were taken at 1 and 3 month intervals. The design for this experiment is illustrated in the following flow chart.

During the alternating treatments phase each child was set a frequency aim before baseline conditions would be reinstated. These performance aims were subjectively selected to represent the range of frequencies or overlearning trials thought to predict fluent performance based on an adult’s performance of the tasks. Each child’s frequency aim or overlearning criterion is listed below.

Roger.

Frequency based performance aim: To achieve greater than 70 correct per minute for 3 intervals in a row when see-saying the Set 1 “how many?” questions when taught using self-paced training procedures.
Sharon.

Frequency based performance aim: To achieve greater than 100 correct per minute for 4 intervals in a row when answering the Set 1 “how many?” questions when taught using self-paced training procedures.

Evan.

Overlearning performance aim: To achieve 100% correct for 10 intervals in a row when answering the Set 2 “who?” questions when taught using time-controlled training procedures.

Nick.

Overlearning performance aim: To achieve 100% correct for 8 intervals in a row when answering the Set 2 “who?” questions when taught using time-controlled training procedures.
Frequency based performance aim: To achieve greater than 70 correct per minute for 3 intervals in a row when answering the Set 1 “who?” questions when taught using self-paced training procedures.

**Procedure**

**Baseline**

Trainer and child sat facing each other, on opposite sides of the table. The trainer set the timer to count up from 0, shuffled the Set 1 (either “how many?” or “who” depending on the child) of flash cards and handed them to the child. The trainer then said, “When I say ‘go’, read the question on the first card, say the answer out loud and then move onto the next card. Keep going until you have completed the entire set of 10 cards. Go as fast as you can and good luck. Ready, set, go.” The trainer then started the timer counting down. Upon the completion of the last card the timer was stopped, the time noted down and a token was given to the child. The procedure was then immediately repeated with the second set of flash cards and then they were given access to the rewards tray to pick whatever they wanted.
With sound.

This procedure was identical to baseline with both sets being presented with the inclusion of having music playing (popular music radio station). The volume of the music was approximately the same as a human voice at a comfortable speaking volume.

Hear-Say application.

The procedure was identical to baseline except the trainer said to the child, “I will read out each question written on the flash cards. After I have finished reading a question, please say the answer. If you don’t know the answer, say, ‘pass’ and I’ll read out the next question. We’ll keep going until you have completed the entire set of 10 cards. Answer as fast as you can and good luck. Ready, set, go.” Both sets of questions were tried.
Alternating Treatments

**Self-paced training.**

The trainer set the timer to count up from 0, shuffled Set 1 of the flash cards and handed them to the child. The trainer then said, “When I say ‘go’, read the question on the first card and say the answer out loud. If you don’t know the answer, turn the card over and read the reverse side, and then move onto the next card. Keep going until you have completed 10 cards or until I say ‘stop’. Go as fast as you can. You are free to go as fast as you like and, if you think you got a card wrong, then you can try again for the correct answer. Good luck. Ready, set, go.” The trainer then started the counter. During the interval, the trainer gave verbal praise and encouragement for about every 3rd correct response. If the child had not completed all of the items within 20-s then the trainer said, “stop” and tallied the number of corrects and errors. Otherwise, upon completion of the last card, the trainer stopped and wrote down the time that it took the child to complete the 10 cards alongside the correct and error tally. If the child equalled or beat their previous rate they were awarded a token paired with praise and encouragement. If the child recorded a slower rate then only praise and encouragement were given. The child was given access to the reward tray after earning 6 tokens. Training continued until the child met his or her criterion.
Time-controlled training.

Following a self-paced training interval the trainer counted the number of flash cards attempted, and then selected the same number of cards from Set 2. The timer was set to count up from 0, the flash cards were shuffled and handed to the child. The trainer then said, “When I say ‘go’, read the question on the first card, say the answer out loud or, if you don’t know it, turn the card over and read the answer. You will spend 6-s (or 12-s for Nick) on each card before moving onto the next card, so take your time. I’ll say ‘go’ to let you know when it’s time to move onto the next card. We’ll keep going until you have completed all the cards. Good luck. Ready, set, go.” The trainer then started the counter and every 6-s (12-s for Nick) said, “Go”. The trainer then started the counter. The trainer gave verbal praise and encouragement for about every 3rd correct response. Upon the completion of the last card, the timer was stopped and the correct and error count was written down. A token and further praise and encouragement were then delivered if the child equalled or beat the previous number of correct flash cards. Only praise and encouragement were given if the child scored a lower score. Once the child had accumulated 6 tokens they were give access to the rewards tray. Training continued until the child met their criterion.
Roger, Sharon, Evan, Nick and Pat’s results are presented in Figures 6.1 to 6.5 (the raw data appear in appendices P through T). During baseline none of the children answered any of the questions correctly. During the alternating treatments all of the children demonstrated improvements with both methods with errors eliminated more quickly under time-controlled training conditions. Roger received 15 intervals of self-paced training to reach a rate of 86(0) on Set 1 and his errors had completely dropped out by the 7th interval. He achieved 100% accuracy on Set 2 (time-controlled training) by the 6th interval. Sharon achieved a high rate of 120(0) with errors dropping out by the 6th interval and achieved 100% accuracy on Set 2 (time-controlled training) just one interval earlier.

For Evan, Nick and Pat the difference between the two methods was far more noticeable. Compared to time-controlled training, all three made far more errors when taught via self-paced training methods, particularly Nick who took twice as many intervals to achieve 100% accuracy under self-paced training conditions. The data also show that the time-controlled training aims were reached in fewer intervals than the self-paced frequency aims.
Figure 6.1. Roger’s response rate on the 2 sets of (“how many?”) questions over the different experimental phases.
Figure 6.2. Sharon’s response rate on the 2 sets of (“how many?”) questions over the different experimental phases.
Figure 6.3. Evan’s response rate on the 2 sets of (“who?”) questions over the different experimental phases.
Figure 6.4. Nick’s rate of response on the 2 sets of (“who?”) questions across the different experimental phases.
Figure 6.5. Pat’s rate of response on the 2 sets of (“who?”) questions across the different experimental phases.
Upon achieving their individual aims, all of the children were immediately given baseline assessments. The data collected showed that all the children improved their speed and accuracy levels when compared to their initial baseline results.

All 5 children also demonstrated that the rate and accuracy achieved on Set 1 was almost identical to that achieved on Set 2, regardless of the different performance aims. All 5 children also consistently demonstrated that the rate achieved under self-paced training conditions with Set 1, was also the rate that they could perform Set 2. This was true even though there was some variation in the rates achieved by each child.

Probes taken, of hear-say rates and see-say rates with the radio on, of the two sets of questions are nearly identical. The results from the probes also show that: (1) Roger and Evan’s rates on both sets momentarily dropped when the “with sound” conditions were introduced, and (2) dropped by about half under hear-say conditions. As illustrated in the Figures, Roger achieved rates between 20(0) and 27(0) on both sets, Sharon scored 27(0) on all her attempts, and Evan, Nick and Pat scored between 15(0) and 21(0).

1 month later another series of baseline assessments were administered. Sharon, Roger and Evan’s performances were almost identical to their previous baseline results. Pat and Nick’s performances were generally about 5 to 10 counts per minute slower on Set 1 (self-paced training), and about 3 to 5 counts per minute slower on Set 2 (time-controlled training). Another follow-up assessment was then given 3-months after the initial training. At this time Evan and Nick’s performances were nearly identical to their previous assessments. Both Pat and
Sharon’s performances initially dropped to 24(0) and 75(0), respectively, although then recovered to rates similar to their previous assessments. Roger’s performance also slowed at the first interval, scoring 60(0) on both sets, and scoring between 30(0) and 35(0) at the first interval of the “with sound” condition, scoring on both sets. Otherwise his performance was very similar to his previous baseline assessment.

Discussion

The current experiment demonstrated with all 5 children, that the effects of self-paced training and time-controlled training were nearly identical when matched for the same amount of practice opportunities and the reinforcement used during practice. Following the alternating treatments phase, the data show that for each child both sets of general knowledge questions were performed at a similar speed and accuracy at the first return to baseline phase, and again at a 1- and 3-month follow-up. Both sets of questions were also performed at similar rates when tested with music playing in the background, and again when the questions were presented via another learning channel (from see-say to hear-say). These similarities were also demonstrated at a 1-, and 3-month follow-up. Given the similarity of the outcomes, the children’s performances were most likely determined by factors common to both self-paced training and time-controlled training methods such as: the same amount of practice; the use of the same variable-ratio schedule of reinforcement in both conditions; the use of
SAFMEDS; and the presence of immediate feedback during acquisition (the children were free to read the answer on the back of the card throughout the alternating treatments phase). The performance rate reached by each child on the hear-say assessments was limited by the rate at which the trainer could read out each question. Because of this restriction, rates achieved under the hear-say condition cannot be validly compared to the rates reached under see-say conditions.

One difference in the results was shown in the data during the alternating treatments phase, which may highlight some variation between the two methods. The results show that time-controlled training procedures were associated with fewer errors (most clearly demonstrated by Evan, Nick and Pat all who learnt the “who?” questions) during practice.

Both procedures yielded near identical rates of responding – a finding that requires some interpretation. It was possible that some carryover or alternation effects promoted this similarity. One potential influence may have come from the children practicing “flipping the cards quickly” under the self-paced training conditions. The children not only learned to answer the general knowledge questions, they also learnt how to flip the cards quickly. Graf (1994) identified that if a student couldn’t flip the cards at a rate needed to achieve his or her performance aim then it would be almost impossible, without further practice at flipping the cards, to achieve that aim. Graf (1994) then described that teaching card flipping to fluency (using a blank deck) has been used to successfully help children achieve their performance aims. Within the boundaries of the current
Experimental design, it is impossible to know if the outcomes associated with time-controlled training would have occurred without the children concurrently engaging in self-paced training. Given this uncertainty, it is unknown if time-controlled training alone would have resulted in the same rates, therefore this scenario remains to be tested and seems worthy of further inquiry. Still, this potential confound does not substantially reduce the significance of the data collected here, because the converse would also be true. That is, if the students weren’t fluent with the material after the time-controlled training trials then this too would limit their performance rate - no matter how fluent their “flipping” skills were. Therefore, the data certainly show that time-controlled training practice was effective enough for teaching the question-answer pairs so that they could be performed at the rates demonstrated.

Some other differences between the two methods came from anecdotal reports from the children. All the children indicated that initially they found self-paced training more difficult and challenging than time-controlled training. However, once they had reduced their error rates to near 0, all of the children said that self-paced training was a lot more fun than the time-controlled training practice sessions. Binder and Sweeney (2002) and Lindsley (1992) have gathered similar reports. Lindsley (1992) described how self-paced training and achieving fluency was fun, generates interest and understanding, and removes the “desire” to cheat. Binder and Sweeney (2002) and Binder and Bloom (1989) described that fluency-building strategies have helped to keep training groups interested which, in turn, has kept them practicing. Perhaps this is the key ingredient to the
success of fluency-building over simply practicing ad nauseam and why the strategies used by fluency-builders are particularly powerful.

The clear outcome of these results was that self-paced training and time-controlled training yielded very similar outcomes. Within the confines of the current design it appeared that the speed at which practice occurred did not determine whether the children developed fluency or not. However, there were some differences that showed that time-controlled training eliminated errors sooner than self-paced training, but self-paced training resulted in faster accelerations and was more enjoyable for the participants. In application, the results of this experiment suggest that a combination of time-controlled training and self-paced training strategies could be used to tailor a curriculum that is both challenging, effective and meets the needs of learners.
GENERAL DISCUSSION

The purpose of this study was to determine if frequency-building procedures could be a viable solution to the problem of skill generalisation and maintenance for young children with autism. The results showed that imitation, tracing, writing, simple addition, and phoneme reading skills, taught to young children with autism were affected by frequency-building procedures in ways that were consistent with non-autistic populations. Most aspects of RESAA were also achieved. As a consequence these findings support frequency-building to fluency as an effective programming tactic for promoting skill generalisation and maintenance for young children with autism. All of the children (except Chris’ o-loops shown in Figure 3.3) showed skill retention over the short (e.g. 2 weeks) and long-term (e.g. 3 months) after practicing under frequency-building conditions to fluency-based frequency aims. Plus, the data collected in experiments 1 through 5 showed: (1) increased gains on measures of skill application, and (2) increased stability on assessments of skill endurance with continued practice under frequency-building conditions. Furthermore, discrete trial training combined with frequency-building procedures resulted in greater gains, both within and across skills, than following discrete trial training alone when teaching gross motor imitation skills (see Figures 1.3 and 1.4; and Table 1.4). Incidental observations of the children outside of training and information collected from parent interviews also suggested that generalised gains were made with all of these children across people and settings. However, a data based assessment of these gains would provide better support for this conclusion.
These collective results not only support the inclusion of frequency-building procedures within early intervention programs, but also add support to the generative outcomes described by previous reviews with other populations and skills (Binder, 1988; 1993; 1996; Johnson & Layng, 1992; 1994; 1996; Kubina & Morrison, 2000; Lindsley, 1990; 1991; 1992; 1996a; 1996b; 1996c; Maloney, 1998). These findings also extend the work of previous studies of skill retention (Bucklin et al., 2000; McDade, 1998; Ollander et al., 1986), endurance (Binder 1979 cited in Binder, 1996; Binder et al., 1990) and application (Bucklin et al., 2000; Haughton, 1972) by providing results consistent with expectations but with different skills, participants, and employing carefully controlled single case designs. These findings suggest that frequency-building to fluency could be added to the strategies outlined by Stokes and Baer (1977), Stokes and Osnes (1989), White et al. (1985), and Haring et al. (1985), although further independent replication of this study, with consistent results, would strengthen this claim.

Aims were formulated and tested and all the findings were consistent with previous claims. Firstly, the rate of target skills positively predicted the quality and quantity of most skills measured across the application probes for experiments 1 through 5. Skills that failed to improve could be accounted for by skill deficits not targeted during the intervention. For example, in experiment 5 it was not surprising that the children only showed improvements for reading words that were constructed from phonemes practiced under frequency-building procedures. Similarly, it was not surprising that frequency-building addition sum problems only positively affected the performance of other addition sums.
problems and failed to change subtraction rates. Secondly, preliminary evidence suggested that more exemplars were preferable to fewer during frequency-building practice. The differences between the children taught with a differing number of exemplars in experiment 1 were large and consistent, although further controlled analyses are needed because single case experimental designs are limited to within-subject comparisons. Nonetheless, the data are consistent with Stokes and Baer (1977) and White et al. (1988), and support the current practice to use more exemplars rather than fewer when building skills to fluency (Binder, 1996; Johnson & Layng, 1992; 1994). Thirdly, the results from experiment 1 also demonstrated that a controlled-operant task could be modified and practiced to rates high enough to achieve RESAA criteria. Fourthly, the results from experiment 6 showed that discrete trial training can be as effective as frequency-building if matched for reinforcement and practice, however was less efficient and rated less enjoyable by participants. Finally, the results suggest that frequency-aims gathered from studies of nonautistic populations may be used to set frequency-aims for young children with autism. This finding adds support to the claim that frequency aims can be universally applied across learners and settings (Haughton Binder, 1993; Haughton, 1971; 1972; 1977; 1980; 1981; Lindsley, 1992; Maloney, 1998; Starlin, 1970).

The data also showed corrects and errors multiplying and dividing independently of each other and that learning was depicted linearly on the celeration charts. These patterns of responding were particularly noticeable during the early stages of frequency-building. An unexpected finding was that the frequency of composite repertoires gradually emerged as a function of the frequency of the
component skills. This relationship could also be described by a multiply/divide relationship based on the proportion of gains between rates of the component skills and of the composite performance. For examples of this relationship see the celerations and covariations in experiments 3, 4, and 5. Some sudden jumps or leaps were observed for some applications and adductions, however generally the rate of an application skill gradually increased as the rate of the target behaviour increased.

Contributions to behavioural fluency theory

A defining feature of the frequency-building procedures was the significant amount of practice that they supported. Even though overlearning and frequency-building procedures achieved identical outcomes in experiment 6, the participants still indicated a preference for practicing with frequency-building strategies after errors were eliminated. More importantly, perhaps a key benefit lay in the fact that the frequency-building strategies were able to keep all of these children (most with severe disabilities and behavioural problems) practicing repeatedly on the same task for many months. Recall that many of these children had difficulty keeping on-task in their home-based, discrete-trial programs. Therefore, simply collecting the data shown in this thesis is a strong testimony for using frequency-building procedures with children with autism. Elizabeth Haughton (1992 cited in Johnson & Layng, 1996) suggested that fluency “...increases creativity, creates high energy, increases time management, and is
the best natural reinforcer for all it makes possible…” (p. 287). Perhaps frequency-building presented contingencies that were sufficient to support the practice needed to reach fluency. Lindsley (1992) suggested that developing fluency and fluent performance was fun, and generates interest and understanding. Perhaps “fun” is a by-product of effective reinforcement coupled with free-responding instruction?

The frequency-building procedures also illustrated that increased, accurate responding was achieved by employing dense, variable-ratio (VR) schedules of reinforcement coupled with procedures that allowed free-responding. These nonverbal, procedural descriptions of frequency-building procedures may prove to be extremely useful for applying frequency-building practice for learners who do not follow verbal commands (either through a lack of comprehension, sensory deficit, or any other impediment). By demonstrating that dense, VR schedules coupled with free-responding procedures had a frequency-building effect for young children with autism was significant to the success of this thesis, and may prove significant to the application of frequency-building procedures in many future early intervention plans for young children with autism. It certainly appears to be good practice to contain descriptions of reinforcement schedules when talking about frequency-building strategies. Schedules of reinforcement may also be an independent variable worth manipulating to determine the effects that different programmed schedules have on the acquisition of fluent skill development.
The reversal designs, embedded within the frequency-building phases across the experiments, also consistently showed that the rate and accuracy of a response could be significantly diminished by increasing the length of the intervals during the early stages of learning. Often, when intervals were increased, the children would respond first with a short, accurate burst of performance followed by off-task, disruptive behaviour, and finally tantrums. Similarly, the results also showed that by reintroducing shorter intervals that the rate and accuracy of a response could be returned back to previous levels – thus eliminating all off-task behaviour. This scenario describes a lack of skill endurance and a lack of instructional compliance. By examining the contingencies the clear differences between longer and short intervals were: (1) more responses were required in succession, which is potentially more effortful, and (2) there were longer delays between earning the tokens and exchanging them for the primary reinforcer (e.g. a toy, lollies, games etc.) during longer practice intervals.

Increasing intervals has been shown to result in off-task behaviour before (Binder et al., 1990) although there was no reference to the effects of reinforcement or reinforcement delay. Certainly longer intervals do result in changes to the delivery of reinforcement, and this might also be a contributing factor that accounts for the change in performance. Therefore, part of the effect may be explained by insufficient primary reinforcement per response, per unit of time (i.e., ratio strain). Most importantly, the data from the current study also demonstrate that well practiced, high-rate, accurate responses can be maintained with far less primary reinforcement per unit of time than low rate, inaccurate responses. This is a well known effect of variable ratio schedules (Baron &
Leinenweber, 1995; Killen & Hall, 2001; Stephens, Pear, Wray & Jackson, 1975; Stoddard, Sidman, & Brady, 1988; Weiner, 1969). The significance of these conclusions is that schedules of reinforcement are included as part of the definition of behavioural fluency, which has been lacking in the behavioural fluency literature (Kubina & Morrison, 2000). The strength of these conclusions needs to be tested, however a lot could be gained by including what is known about reinforcement schedules and applied behaviour analysis when studying the effects of behavioural fluency in the future. Precision teaching and behavioural fluency literature has described a fluent response as one that retains, endures, is stable, can be applied easily and adduces with other skills. However, based on the applied nature of Precision Teaching, there have never been any documented references to the basic and applied research on effort, preference, reinforcement schedules, behavioural momentum, motivational effects (establishing operations), response strength, or response efficiency — all of which seem to be tacting similar behavioural phenomena. However, as behavioural fluency grows and begins to be empirically studied and validated, perhaps adding reinforcement to these descriptions might be useful. Particularly when designing applied interventions that require the use of explicit reinforcement with little verbal instruction (i.e. early intervention programs). Perhaps measures of schedule and reinforcement rate could be included on standard celeration charts in the future.

Based on some of the observations collected here, future research could also examine whether applications and adductions can be mediated. Binder and Sweeney (2002) suggested that this could be the case. Therefore, what has been discussed about programming generalisations (Stokes & Baer, 1977) might also
be applied to applications and adductions and make these events more likely.

The analysis of fluency then arrives at a new point. Rather than asking questions like, “what frequencies do adductions occur?” researchers might rather ask, “what environmental factors help to establish adductions and applications after retention and endurance have been demonstrated?” Retention and endurance can be determined directly by measuring a single target skill. However, since applications can occur over many environments and behaviour, they are widely influenced by other factors. Therefore, after retention and endurance have been achieved it may be just as valid to ask, “Why certain adductions/applications don’t occur?”

Contributions to frequency-building procedures

A number of procedural alternatives were generated, tried and evaluated in this thesis. This thesis is a “first step” towards an analysis of behavioural fluency for young children with autism. Therefore, as this thesis has been prompted by the research before it, hopefully the following suggestions and observations will lead to further critical examination and replication by the studies that follow it. Some of the conclusions that require further investigation include:

1. When balanced for the total amount of time spent practicing, 10-s sprints generally produced steeper celerations than longer intervals (e.g. 30-s)
and this effect was most noticeable during the early stages of frequency-building.

2. Preliminary results suggest that smaller sets of stimulus exemplars can be used during frequency-building but might require more practice sessions to reach fluency than if larger exemplar sets are employed.

3. When fluency is desired and there is no option but to use teacher controlled stimuli (e.g. imitation training), conditions that mimic true free-responding procedures can be used to achieve fluent rates of performance. This can be accomplished if the teacher allows the learner’s responses to control the presentation of discriminative stimuli.

Furthermore, based on the results achieved here, some 1-minute frequency aims were generated. In summary, these were:

1. See-do gross motor movements at a rate between 60 and 80 per minute.
2. Free-trace lines on a sheet of paper at about 100 per minute.
3. Free-write tally slashes a rate between 450 and 550 per minute.
4. Free-write o-loops at a rate of about 240 per minute.
5. See-say single-digit addition facts at a rate of about 100 per minute.
6. See-say phonemes at a rate of about 100 per minute.
7. See-say single words answers to SAFMEDS between 100 and 120 per minute.
Finally, there were some experimental design modifications that occurred following each experiment. Based on those conclusions it was suggested that:

1. If the variable of interest is the length of the intervals used then the design should balance the total time in practice per session. For example, if 10-s intervals are practiced 12 times per session, then 30-s intervals would be practiced only 4 times per session. In this way, time in practice is equal.

2. If the variable of interest is the outcomes of practice then the number of response opportunities between conditions should be kept constant. For example, if during frequency-building a learner completes 25 SAFMEDS, then the comparison condition should also have 25 SAFMEDS. Similarly, for consistency the amount and schedule of reinforcement used should also be the same between conditions.

3. If probes for applications are of interest, then present application probes with sufficient time either before or after any other training to reduce potential carryover effects (e.g. unwanted behavioural momentum). Similarly, if an application probe is going to be administered regularly then perhaps an equivalent form of this probe could be reserved for baseline and follow-up only. This would be done to measure, or control, the possibility that learning happened during the probes.
The current thesis provided an application of behavioural fluency procedures for young children with autism across tasks that commonly feature in most early intervention programs (Lovaas et al., 1981). The findings support behavioural fluency descriptions (Binder, 1996) and add to the empirical database of fluency investigations. Skinner (1953) stated, “…frequency of response…is a sensitive “dependent variable” which has been found to function of many subtle experimental conditions…” (p.71). However, equally important are adequate description of the conditions that affect the frequency of a response – namely the frequency of reinforcement (Ferster & Perrott, 1968). Therefore, descriptions of reinforcement featured more prominently in this thesis than in other behavioural fluency publications (Binder, 1993; 1996; Johnson & Layng, 1992, 1994; 1996; Lindsley, 1971; 1991; 1992; 1996a) for the purpose of extending those findings and of emphasising reinforcement as a key variable of interest when studying behavioural fluency.
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Appendix

Table 6.1

The 4 Sets Of Questions Used in Experiment 6

<table>
<thead>
<tr>
<th>Set</th>
<th>Items</th>
<th>Question</th>
<th>Answer</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>“Who?” – set 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Who wrote Goodbye Columbus?</td>
<td>Philip Roth</td>
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<tr>
<td></td>
<td></td>
<td>Which folk singer died of Huntington’s Chorea?</td>
<td>Woody Guthrie</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Who allegedly killed officer J.D. Tippit?</td>
<td>Lee Harvey Oswald</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Who created the fictional Character Zooey?</td>
<td>J.D. Salinger</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Who is known as The Father Of Geometry?</td>
<td>Euclid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Who headed the Gestapo?</td>
<td>Heinrich Himmler</td>
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<tr>
<td></td>
<td></td>
<td>Who founded the Australian Democratic Party?</td>
<td>Don Chipp</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Who was made the first honorary citizen of the USA?</td>
<td>Winston Churchill</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What character did Jim Banks create in 1921?</td>
<td>Ginger Meggs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Who played George Smiley on TV?</td>
<td>Sir Alec Guinness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“Who?” – set 2</td>
<td></td>
</tr>
</tbody>
</table>
Who delivered fireside chats? Franklin Roosevelt
What was Cinderella’s real name? Ella
Who wrote Matters For Judgement? Sir John Kerr
Who wrote The Red Badge of Courage? Stephen Crane
Who narrates the Sherlock Holmes stories? Dr. Watson
Who won the 1982 archibald prize? Eric Smith
What Australian premier published a cookbook? Don Dunstan
Who was Lancelot’s son in Arthurian legend? Galahad
Who was Ben Casey’s boss? Dr. Zorba
Who wrote Sexual Politics and Flying? Kate Millett

<table>
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<tr>
<th>Set</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question</td>
<td>Answer</td>
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</tbody>
</table>

“How Many?” – set 1

- How many holes of golf are normally played in the Australian Open? 72
- How many squares are there on a chessboard? 64
- How many astronauts manned each Apollo flight? 3
- What’s the minimum number of bars on an abacus? 9
- How many Australian prime Ministers have died in office? 3
- What is considered the luckiest number worldwide? 9
- How many colours are there in a rainbow? 7
- How many holes in a standard horseshoe? 8
- How many times thicker is blood than water? 6
How many steps in John Buchan’s novel? 39

<table>
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<tr>
<th>Set</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>“How many?” – set 2</td>
<td></td>
</tr>
<tr>
<td>How many pawns does each player have at the start of a chess game?</td>
<td>8</td>
</tr>
<tr>
<td>How many cups of butter in a pound?</td>
<td>2</td>
</tr>
<tr>
<td>How many eyes are there in a deck of 52 cards?</td>
<td>42</td>
</tr>
<tr>
<td>How many minutes for light to reach the Earth from the Sun?</td>
<td>8</td>
</tr>
<tr>
<td>What’s the voltage of most car batteries?</td>
<td>12</td>
</tr>
<tr>
<td>How many 10ths of the Earth’s surface lies under water?</td>
<td>7</td>
</tr>
<tr>
<td>How many children did Adam and Eve have together?</td>
<td>3</td>
</tr>
<tr>
<td>How many bulls are killed in a formal bullfight?</td>
<td>6</td>
</tr>
<tr>
<td>How many centimetres high is the centre of a tennis net?</td>
<td>91</td>
</tr>
<tr>
<td>How many stripes are there on Israel’s flag?</td>
<td>2</td>
</tr>
</tbody>
</table>