EFFECT OF A STIMULUS SHAPING PROCEDURE ON FLUENT LETTER SOUND ACQUISITION

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Numerous studies have evaluated and confirmed many benefits of errorless learning and fluency-based procedures. The purpose of this study was to evaluate the benefits of combining an errorless learning procedure, stimulus shaping, and fluency-based procedures to teach see/say letter sound discriminations to three preschool children. Participants were taught 6 letter sounds using a hear/point stimulus shaping procedure followed by a see/say fluency-based procedure. A second letter set was taught using only the fluency-based procedure. Results showed that combining the procedures reduced the amount of teaching time by up to 40% and the percent of errors by up to 50%. This preliminary evidence shows exceptional promise in application of this combination of procedures to teach letter sounds to preschool children.
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INTRODUCTION

Imagine for a moment that you cannot read. Only lines and dashes appear on this page, not letters and words full of meaning. The same thing happens when you look at a storybook, map, or street sign. Imagine the difficulties you would encounter during everyday activities. The ability to read opens up opportunities across the lifespan, including access to more complex information, new reinforcers, and escape from or avoidance of undesirable situations. For example, learning to read can help you follow instructions on a recipe, increase job opportunities, and allow you to read a map when you are lost. Due to the scope of the impact that reading skills can have on a person’s life, reading skills can be categorized easily as behavioral cusps, defined as “a behavior change that has consequences for the organism beyond the change itself” (Rosales-Ruiz & Baer, 1997, p. 534).

The National Institute for Literacy asserts that the “skills and knowledge to understand how phonemes, or speech sounds, are connected to print, the ability to decode unfamiliar words, and the ability to read fluently” are instrumental in acquiring functional reading skills (2009). Developmental research suggests that children who master these skills at an early age are more likely to learn to read earlier and more proficiently than those who do not (Siegler & Richards, 1982).

Gibson and Levin (1980) note that typically-developing children reverse letters (e.g., b and d) up to age 9 and nearly half of all kindergarteners regularly reverse letters. Gilbert (1978) suggests teaching often confused stimuli together. Teaching children to discriminate between these two competing letter sounds early in learning may reduce the number of discrimination errors over time (Gilbert, 1978).
Traditional approaches to reading instruction often include trial-and-error procedures. In trial-and-error learning learners are repeatedly exposed to learning conditions and, over time, make fewer and fewer errors based on the consequences that followed earlier responses (Pierce & Cheney, 2004). Using this approach, many errors occur that can lead to more errors (Sidman & Stoddard, 1966), maladaptive behaviors (Bradley-Johnson et al., 1983; Touchette & Howard, 1984), and increased latency to respond (Terrace, 1963). Fortunately, research suggests that errors such as these can be reduced by modifying teaching procedures (Doucette, 2007; Mueller & Palkovik, 2007).

Errorless learning procedures are designed to teach new behavior to accuracy with few or no errors (Terrace, 1963). Lancioni and Smeets (1986) suggest that the goal of errorless learning procedures is to teach the behavior with fewer than 10% incorrect responses. One procedure, stimulus shaping, involves slowly changing the topography of a stimulus the participant can discriminate accurately to the terminal stimulus across successive learning trials (Doucette, 2007; Etzel, 1997). For example, when teaching letter sounds an apple, which effectively evokes the response “a” from a learner, may gradually change shape to the letter “a” across successive trials. McCartney and Leblanc (1997) note that in stimulus shaping procedures the stimulus contains a criterion-related cue that does not change much from the initial to the terminal stimulus and remains a key component necessary to make the terminal discrimination. Stimulus shaping procedures have been shown to effectively and efficiently teach a variety of skills, such as shape (Schilmoeller, Schilmoeller, Etzel, & LeBlanc, 1979) and letter sound discrimination (Doucette, 2007), with fewer errors and require less teaching time.
than other teaching procedures (Lancioni & Smeets, 1986; Sidman & Stoddard, 1966).

Doucette (2007) compared the effects of stimulus shaping using a program derived from Gilbert’s *Praxis Reading Series* (1967) and a fluency-based procedure to teach letter sounds, measuring acquisition, number of errors, teaching time, retention, and generalization. In the stimulus shaping trials, participants were required to point to the shape that corresponded with the letter sound that the experimenter stated (hear/point learning channel). With the fluency-based procedures participants learned to say the sound of the letter written on a flashcard (see/say learning channel). Results indicated that fewer trials were necessary to reach criterion in the stimulus shaping trials, while little retention or generalization to the see/say learning channel was observed. In contrast, retention and generalization to the hear/point learning channel were seen in letter sounds acquired using the “errorful” procedures. However, practice effects may have contributed to these results as the participants completed a much higher number of trials with the “errorful” procedures than the stimulus shaping procedures. In addition, in the “errorful” teaching condition the number of errors was so high that the number of stimuli was reduced from 6 to 2 or 3 to increase the participant’s success. As the participant’s performance met an accuracy criterion, an additional letter was added until all 6 letters were presented together again. This adaptation was not required in the errorless teaching condition.

Doucette (2007) noted that the performance of several participants under the age of 5 did not reach fluency and, also citing the need to add an intraverbal mediation procedure, suggested that the use of these particular procedures to teach letter sounds to children under five may not be optimal. However, once the intraverbal mediation
training was completed, the participants were able to complete the stimulus shaping steps.

Although errorless learning procedures can reduce the number of errors and teaching time required to acquire a new discrimination, there are a number of disadvantages. First, stimulus shaping materials take time and resources to develop. There is not currently a computer program or widely available, ready-to-use source for materials to teach letter sounds. Additionally, studies suggest that discriminations learned with errorless learning techniques may not generalize across learning channels and may not maintain across time as well as other procedures (Doucette, 2007; Duffy & Wishart, 1994).

Behavioral fluency has been defined as accuracy plus speed of responding (Binder, 1996). Binder, Haughton, and Bateman (2002) stated, “When students lack fluency in the foundation skills, performance requiring application of those skills is likely to be painfully slow, difficult, and full of errors” (p. 4). The ability to say letter sounds when you see the corresponding letter is a large part of the early foundation of reading skills. Developing this skill to fluency can increase the probability of retention and maintenance of the skill over time, endurance of performance, and application of the skill to decode words quickly and accurately (Binder et al., 2002). For a skill to be “fluent” it must meet a particular aim, or goal. Research indicates a range of fluent performance for see/say letter sounds from 60 to 120 sounds/min depending on the material presentation. Maloney (2001) defined a fluent letter sound in isolation performance range of 60-80 sounds/min. Regarding the possibility of a high rate of errors when using fluency-based procedures, Binder and Watkins (1990) say that
suppression of errors can slow learning and when children are encouraged to respond at a high rate regardless of errors, learning rates increase. Errors are viewed as an integral part of the learning process.

Gilbertson et al. (2007) compared children’s letter naming fluency using see/say or hear/point teaching procedures. Similar to Doucette’s (2007) procedures, participants either named a letter on a piece of paper or pointed to a letter that corresponded to a letter that was stated by the experimenter. However, in this study, the researchers used only fluency procedures, not stimulus shaping, to teach the letter names in both the see/say and hear/point learning channels. Results showed that see/say fluency methods resulted in higher rates of acquisition and better retention of letter naming than hear/point procedures.

Research has indicated that errorless learning procedures can be beneficial to learning skills quickly with few errors. However, it is less clear what, if any, benefit the procedures provide when combined with other approaches when teaching letter sound discriminations.

To help clarify the benefits of combining procedures, this study was conducted with the following question in mind: How will teaching hear/point letter sound discriminations to preschool children using stimulus shaping procedures prior to implementing see/say fluency procedures effect the teaching duration, number of errors, and retention of letter sounds?
METHOD

Participants

Three typically-developing children, between the ages of 3 and 5 at the start of the project, participated in the study. All participants were recruited from a public preschool. David, a 5-year-old male of Caucasian and African American descent and April, a 4-year-old female of Mexican descent were students in the same classroom. The third participant, from a second classroom in the preschool, was Jamie, a 3-year-old female of African American descent. A fourth participant was withdrawn from the study due to inconsistent attendance and participation. All participants spoke English as their primary language. To meet study requirements, the participants could accurately identify no more than 2 letter sounds in each letter set during the preassessment (detailed below).

Setting and Materials

One-on-one teaching sessions took place in a kitchen off a main hallway in the participants’ school. The room contained a table surrounded by 2-4 chairs along with typical kitchen appliances and a wall of cabinets. Materials necessary for each condition were laid out on the table.

Preassessment Materials

Each of the 12 letters used in the study, f, e, a, s, t, i and d, o, u, p, b, v, were printed individually in Helvetica Narrow 130-pt font centered on a piece of 8.5 X 11 in white copy paper. Letter sizes were approximately 1.25 X 1.5 in.

Pre-Training Stimuli

Pre-training stimuli consisted of 6 commonly “known” (i.e., dog, star) pictures
and 6 arbitrarily chosen symbols (refer to Figure 1) presented in two formats. In the first format, 6 (3 “known” and 3 arbitrary) black and white pictures were printed on a piece of white copy paper. The paper was then cut into 2- x 2-in flashcards with one picture centered on the front of each card. Two laminated flashcards of each picture were created. In the second format, the remaining 6 pictures (3 in each category) were arranged in two rows of three pictures on an 8.5- X 11-in piece of white copy paper. The pictures were randomly distributed into six positions on the paper.

Training Stimuli

Hear/point stimulus shaping materials were presented in several formats. Twelve, (2 sets of 6) letters were printed in 2 rows of 3 letters in Helvetica Narrow 130-pt font in black ink on 8.5 X 11 in white copy paper. Letter set 1 included letters d, o, u, p, v, and b. Letter set 2 included letters f, e, a, s, t, and i. Twelve additional stimuli corresponding with the 12 letters were presented. Pictures in set 1 included a duck, pipe, boot, valentine, octopus, and a man pointing up. A flag, snake, table, elephant head, apple, and Indian made up picture set 2 (see Figure 3). Each picture was printed in isolation and centered on a piece of 8.5 X 11 in white copy paper. Additionally, each set of pictures was arranged in 2 rows of 3 pictures on a piece of white copy paper. Next, 24 stimuli, of which 12 resembled the original pictures and 12 resembled the 12 letters (as illustrated in Figure 4) were set up in the same fashion.

See/say training stimuli (see Figure 2) consisted of 12 letters (two sets of 6) printed in Helvetica Narrow 130 pt font in black ink on 8.5- x 11.5-in white copy paper, then laminated. Then the pages were cut into 2- x 2-in flashcards with one letter centered on the front of each card. Eight copies of each letter set were created,
resulting in 48 flashcards/set. Letter set 1 included letters d, o, u, p, v, and b. Letter set 2 included letters f, e, a, s, t, and i. Additionally, a 5- x 5-in red and a 5- x 5-in green card were glued to a piece of copy paper.

General Materials

General materials included standard celebration charts, daily timings charts, clear sheet protectors, binders to hold materials, 2 digital timers, and data sheets. Data sheets incorporated recording space for the stimulus shaping trials, interobserver agreement, participant preference, session duration, number of errors, and pretest and retention test scores.

Response Measurement

During see/say sessions the frequency of correct and incorrect, including skipped, responses/min and the number of timings were recorded. Hear/point measurements included the number of correct and incorrect responses, along with notes about responses (e.g., participant switched a and e sounds). Duration of teaching time for both formats and participant preference were also recorded.

Participant Preference

At the beginning of each session, with the exception of Session 1, the participant was asked, “Do you want to do the cards or the pictures first?” Once both letter sets were being taught with the see/say fluency methods, the participant was asked to point to the set of cards he/she preferred to complete first. The participant’s response was recorded and the session began with the participant’s chosen format.

Practice Opportunities

A practice opportunity was recorded during see/say sessions. One practice
opportunity was defined as one presentation of each flashcard from a letter set.

Timings

A timing was a 30-s period initiated when the experimenter pushed the start button on the timer and presented a succession of shuffled flashcards from one letter set to the participant. Each timing began when the participant initiated a response when shown the letter on the first flashcard and ended when the timer signaled the end of the time period.

Session Duration

The duration of each teaching session was recorded using a digital timer. During hear/point stimulus shaping sessions the timer was started when the first question was asked. During see/say sessions, the timer was started when the student was asked to name the sound of the first flashcard in the first practice opportunity of the see/say sessions. During baseline, the timer was stopped after the participant’s final response of the session. During training session, the timer was stopped as soon as the experimenter finished counting aloud the flashcards representing the participant’s correct responses or the participant responded to the final question in the stimulus shaping procedures. In the event of an interruption longer than 5s that did not pertain to instruction or material setup (e.g., a teacher entered the teaching area to get food out of the refrigerator), the participant requested a break, or he/she left the work area, the timer was paused.

Correct Response

In see/say sessions, a correct response was recorded when the participant accurately vocalized the letter sound of the letter on the presented flashcard within 3s of
the stimulus presentation. In hear/point stimulus shaping sessions, a correct response was recorded when a participant pointed to the letter corresponding with the letter sound stated in the instruction, “Point to ____.” within 3 s of the instruction. In the stimulus shaping steps, a self-correction within 1 s of touching the first picture was scored as correct as long as it was within 3 s following the instruction.

**Incorrect Response**

In both teaching formats, an incorrect response was recorded if the participant’s behavior did not meet the definition of a correct response. A “skip” response, vocalizing or pointing to a letter that did not correspond with the presented stimulus, and an absence of a response were all counted as incorrect responses.

**Interobserver Agreement**

A second independent observer scored each preassessment, pretest, and 35% of training sessions for all participants. Exact agreement of behaviors measured in frequency of occurrence was calculated by dividing the number of agreements by the number of agreements plus disagreements then multiplying by 100. Average agreement was determined by adding all percentages and dividing by the number of sessions.

Agreement across participants was 100% for participant preference and 95% (range 78% to 100%) for session duration. Agreement on correct responses was 97%, (range of 77% to 100%) and agreement on incorrect responses averaged 92% (range of 50% to 100%).
Procedure

General Procedures

One back-to-back teaching session with each set of procedures was conducted each day. Participants chose the order in which the sessions were conducted. Sessions were conducted Monday through Friday, between 10:00 a.m. and 11:00 a.m., and ranged in duration from 1 to 5 min.

To reward participation in the study, praise was delivered following trials and sessions according to the guidelines described in Procedures. Additionally, participants earned up to 2 stickers/day. During preassessment, pretraining, and pretest sessions, both stickers were delivered contingent only upon completing the session. After training began one sticker was delivered contingent on completion of hear/point trials and the other when the participant reached or surpassed his/her daily goal during see/say sessions.

Preassessment

To ensure that participants qualified for the study, they were asked to name the letter and identify the letter sound of each letter used in the study. To meet study requirements the participants had to accurately identify no more than 2 letter sounds in each letter set.

Pretraining

Pretraining was conducted to introduce the hear/point and see/say teaching formats and to teach the “skip” response. “Known” pictures were used to increase the probability of correct naming responses. Conversely, arbitrary symbols were included to
set the occasion to teach the participant to say, “Skip” in the presence of the new stimuli.

*See/Say.* The experimenter stated, “I am going to show you some cards like this one (card held up), and I want you to name the picture on the card. So, if I hold up this card (a star), then you would say, ‘Star.’ If you don’t know the name of the picture, say, ‘Skip.’ Are you ready to start?” After the participant affirmed that he/she was ready, the experimenter said, “Now we are going to say the name of the picture on the card or ‘Skip’ as fast as we can. Ready, set, go!” When the participant stated his/her first response, the 30 s timing began. During the timing, if the participant did not respond within 3 s of the presentation of the card, he/she was reminded to say, “Skip.” See/Say pretraining was conducted until the participant accurately named the known pictures or said, “Skip” without a prompt for 2 consecutive timings across 2 days.

*Hear/Point.* After see/say pretraining was completed, hear/point pretraining commenced. When the experimenter and participant were seated with the materials ready on the table, the experimenter instructed, “I’m going to say a word and I want you to point to the picture of the word I say. So, if I say, ‘Point to flower.’ I want you to do this.” The experimenter then modeled pointing to flower with her index finger. The experimenter continued, “If you do not know what the picture is you can say ‘skip.’ Are you ready to start?” When the participant affirmed that he/she was ready, the experimenter stated, “Point to ____.” Hear/Point pretraining continued until the participant accurately named the pictures or said, “Skip” without a prompt for 2 consecutive sessions. Praise for participation, regardless of accuracy of performance, was delivered at the end of each session.
Prior to the first training session pretests were administered to determine baseline performance of the 12 letter sounds in each learning channel. Participants chose the order of the pretests by pointing to the set of stimuli associated with the pretest they wished to be presented first. Each letter set in each learning channel was tested each day, resulting in 4 pretests/day across a 4-day period.

Hear/Point. The sheet for the letter set chosen by the participant was placed in front of the participant. The experimenter stated, “I am going to say a letter sound and I want you to point to the letter you think it is. If you do not know, you can say, ‘Skip.’ Are you ready?” When the participant affirmed, the experimenter stated, “Point to ____ (letter sound).” If the participant did not respond within 3 s following the instruction, he/she was prompted to choose a letter. No feedback was given regardless of whether the response was correct, incorrect, or the participant stated, “Skip.” Following the test, praise was delivered for completion of the test regardless of performance. After the 6 letter sounds in Letter Set 1 were tested, the same procedures were used to test the second letter set. The same pretests were repeated the following day. On the final 2 days of baseline, the letters’ positions on the page differed from their positions on the first pretest sheet.

See/Say. Prior to each session, the experimenter shuffled the each letter set’s cards and placed them on the table. When the participant chose one pile of flashcards, the experimenter stated, “I’m going to show you a letter and I want you to tell me the sound. If you do not know the sound, you can say, ‘Skip.’ Do the best that you can. Are you ready?” When the participant indicated he/she was ready, the experimenter said,
“Now we are going to say the sounds as fast as we can with the timer. Ready, set, go!” The experimenter started the timer immediately following the participant’s first response. If the participant did not respond within 3 s following the flashcard presentation, the experimenter prompted him/her to say, “Skip.” After each of the participant’s responses, the experimenter placed the flashcards face down in a pile in front of the participant and delivered praise for participation at the end of the timing. The procedures were repeated for the remaining letter set.

**Hear/Point Stimulus Shaping Procedures**

The errorless teaching procedures were derived from Gilbert’s (1967) *Praxis Reading Series* and Doucette’s (2007) study. A binder with pages for each stimulus shaping step was opened to the current step and placed on the table in front of the participant. During the first session a pretest was given in which each participant was instructed to name the pictures associated with the letter group he/she was to be taught using the combined procedures. Each picture was presented individually. The experimenter asked, “What is this?” If the participant accurately named the picture (e.g., an elephant), the experimenter said, “That’s right! That is an elephant.” If the participant responded incorrectly or did not respond, the experimenter said, “That is an elephant.” If the participant did not independently repeat the name within 3 s, the experimenter repeated the statement. After the participant accurately identified each picture without prompts the stimulus shaping procedure began. The stimulus shaping procedure consisted of 6 auditory stimulus shaping and 6 visual stimulus shaping steps, described below. If a participant responded accurately and no step was repeated, 156 trials would be completed across the procedure.
**Auditory stimulus shaping.** First, the auditory stimulus was shaped from the name of the picture to the letter sound across 6 steps. During auditory stimulus shaping steps the pictures, arranged 3 across and 2 down, did not change shape, but did change position on the paper each step. The experimenter stated instructions across the steps as the following example illustrates:

Step 1: “Point to apple”

Steps 2 and 3: “Point to a-a-apple”

Steps 4 and 5: “Point to a-a”

Step 6: “Point to a”

In each step, one trial for each picture occurred.

**Visual stimulus shaping.** Next, the pictures’ topographies were gradually shaped from the “known” pictures into the corresponding letters over 4 steps (refer to Figure 4 for an example). In visual stimulus shaping steps the experimenter’s instruction remained as illustrated in Step 6, (e.g., “Point to a.”) while the pictures began to change to become more similar to the terminal stimuli. The following sequence illustrates the visual stimulus shaping steps:

Step 7: Stimuli were identical to those in Step 6.

Step 8: Six displays of the pictures were presented sequentially. In each display, 1 of the 6 pictures was altered while the other 5 remained the same as the previous display. The experimenter’s instruction corresponded with the changed picture. For example, in the display in which the elephant picture changed, the experimenter instructed the participant to “Point to e.”

Step 8.a.: Stimuli were identical to those in the final display of Step 8.
Step 9: Six displays of the pictures were presented sequentially. As in Step 8, 1 of the 6 pictures was changed in each display while the other 5 remained the same as the preceding display.

Step 9.a.: Stimuli were identical to those in the final display of Step 9.

Step 10: As in Steps 8 and 9, 6 displays of the pictures were presented sequentially, with 1 picture changed to its final form in each display. The sixth display contained the terminal discriminations for all 6 letters.

During all stimulus shaping teaching sessions, two steps were conducted. The first step was a review of the most recent sheet on which the participant had accurately identified at least 5 stimuli. For example, if on Tuesday, Jamie reviewed Step 3 and accurately identified 5 or 6 pictures on Step 4, then Wednesday’s session began by repeating Step 4. Step reviews evaluated retention of the correct responses to ensure that participants were ready to continue to the next step. To move to the next step at any time in the stimulus shaping procedure, the participant’s responses had to contain no more than 1 error. If more than two errors occurred in a step the previous step was repeated. Otherwise, participants advanced to the next step.

The experimenter delivered praise following each correct response. If the participant’s response was incorrect, the experimenter said nothing and moved to the next trial. If the participant did not respond within 3 s following the instruction he/she was prompted to point to a picture.

After the participant completed the stimulus shaping sequence, instruction with the same letter set with the see/say fluency procedures began.
Intraverbal Mediation Training

Two participants, April and Jamie were taught an intraverbal statement to facilitate transition to Step 4 of the stimulus shaping procedures. Step 4 is the first step in which the name of the picture is no longer stated in the instruction. Prior to intraverbal mediation training, participants were not required to say the name of the picture as they pointed.

Following 3 consecutive days when the participant accurately responded to fewer than 5 stimuli, the procedure was introduced. After the experimenter stated the letter sound twice, the participant was to say and point to the corresponding picture. For example, when the experimenter stated, “Point to a-a.” the participant was to say and point to “apple.” If the student correctly responded across 2 sessions, the intraverbal was determined have been acquired.

After a number of sessions, neither student had acquired the intraverbal with the aforementioned procedures so new intraverbal mediation procedures were instated. The experimenter stated the letter sound one time and the participant was taught to say the name of the corresponding picture, which was not visible. For example, when the experimenter said the sound for the letter ‘a,’ the participant was to say, “apple.” Each letter and its corresponding picture were taught individually until the participant answered correctly across 3 consecutive trials. Next, the second letter and picture name pair was taught followed by combining the two, then the third pair, and so on until all six intraverbal relations were acquired. Stimulus shaping procedures were resumed at Step 4.
See/Say Fluency Procedure

During the first see/say teaching session, the experimenter stated, “I am going to show you a letter and say the sound that it makes. Then, you say the sound that I make.” If the participants repeated the letter sound within 3 s, the experimenter said, “That’s right!” If the participant responded incorrectly, said, “Skip.” or did not respond within 3 s, the experimenter stated the letter sound. If the participant did not independently model the sound within 3 s, the sound was repeated. Trials using this method continued until the participant correctly repeated the name of all 6 letters in the set.

Next, the experimenter stated, “See if you can say the letter sound before I say it.” Letter flashcards were presented one at a time. If the student responded correctly praise was delivered. Incorrect, “Skip,” or no responses within 3 s after the presentation of the flashcard were followed by the experimenter stating the correct sound and prompting the participant to model the sound. Trials continued until each of the letters in the set had been presented twice, for a total of 3 practice opportunities during the first session. During all other sessions, the 3 practice opportunities were conducted according to the latter procedures.

Up to three 30- s timings were conducted after the practice opportunities. No more than 3 timings were conducted each session. A feedback system was developed in order to provide more immediate feedback during the timings without the experimenter verbally noting accuracy of the response. Any card to which the participant responded accurately was placed on a 5- x 5 in green card. Cards to which incorrect responses were made were placed on a 5- x 5 in red card. The green card
was located closer to the participant and the red card was closer to the experimenter.

Prior to the first timing the participant was told his/her daily goal and reminded about the green and red card system. The first goal was based on the highest number of correct responses recorded during baseline. Each session’s goal was one correct letter sound higher than the previous day’s performance. If the participant met his/her performance goal before the third timing, the session was ended. Each participant earned one sticker when he/she met the goal. If the goal was not met the session ended and the next session began with the same goal. The timing with the highest number of correct responses each day was recorded on the standard celeration chart.

Before each timing, the experimenter shuffled 48 flashcards (8 of each letter in the set). The experimenter instructed, “I’m going to show you a letter and I want you to tell me the sound. If you do not know the sound, you can say skip. Are you ready?” When the participant affirmed, the experimenter said, “Now we are going to say the sounds as fast as we can with the timer. Ready, set, go!” The first flashcard was presented and the timer started as soon as the participant emitted the first response. When participant emitted an accurate response, the experimenter placed the flashcard on the green card in front of the participant. Following any incorrect responses the flashcard was put on a red card. When the timer sounded correct responses were counted aloud to the participant. Both correct and incorrect responses were tallied and recorded on the daily timings chart. Based on Maloney’s (2001) standard, the fluency rate criterion was set at 60 sounds/min for 3 consecutive days.

For 2 of the 3 participants, the number of letters in the see/say letter set was reduced due to the high rate of errors. Both April and Jamie’s letters were reduced to 2
letters. The experimenter chose letters that sounded and appeared the most different. When the participant’s performance contained 4 or fewer errors/min, another letter was added. Due to time restrictions, the final letter(s) were added when the participant started see/say fluency procedures with their second letter set.

Retention Test

A test to evaluate retention of letter sounds was conducted 1 and 2 weeks following the final see/say session for Jamie and David, respectively. Testing followed the see/say procedures detailed in Pretest.

Experimental Design

A multi-element design was used to evaluate the effects of teaching hear/point letter sound discriminations on the amount of teaching time, number of errors made, and retention of letter sounds. David and Jamie were taught Letter Set 1 (d, o, u, p, v, b) with only the see/say fluency procedures and Letter Set 2 (f, e, a, s, t, i) with the stimulus shaping followed by the fluency procedures. April was taught the letter sets with the opposite set of procedures.
RESULTS

Figure 5 shows David’s see/say letter sounds results for the letter set (d, o, u, p, v, b) taught with the fluency-based procedure. During baseline timings, David did not accurately say any letter sounds. Over the course of several weeks David’s rate of correct letter sounds continued to increase, surpassing his rate of errors, to a peak of 60 correct sounds/min. During the final training session and follow up session 2 weeks later, see/say letter sound rates were 50 and 40 correct sounds/min, respectively.

Figure 6 displays David’s see/say letter sounds rate for the letter set (f, e, a, s, t, i) taught with the combined procedures. In baseline David accurately stated 2 sounds/min during two separate timings. Following baseline, the stimulus shaping procedure was conducted which required 180 trials with only 19 errors (Table 2). During the first see/say session, David correctly stated 30 sounds/min and this rate continued to increase to a peak of 66 sounds/min in the final training session. A follow-up session two weeks later revealed a slight decrease in rate to 50 correct sounds/min.

April’s see/say letter sounds with the letter set (d, o, u, p, v, b) taught with the combined procedures is shown in Figure 7. No letter sounds were correctly stated in baseline timings. The stimulus shaping procedure was implemented after baseline and completed in 578 trials, 108 of which were errors (Table 2). Due to time constraints, only one see/say session was conducted in which April did not accurately identify any letter sounds.

Figure 8 presents April’s see/say letter sound rates with the letter set (f, e, a, s, t, i) taught with only the fluency-based procedures. During baseline April did not correctly identify any letter sounds. Several sessions into training the number of letter sounds
was decreased and gradually reintroduced according to rules listed in Procedures. April's see/say letter sound rate ended at 16 correct sounds/min with all 6 letters presented.

Figure 9 shows Jamie's see/say letter sounds with the letter set (d, o, u, p, v, b) taught using only the fluency-based procedures. After accurately identifying 0 letter sounds in baseline trials and continuing to emit a high rate of errors, Jamie's, like April's, letters were reduced then gradually reintroduced. Jamie's performance peaked at 22 correct letter sounds/min. During the final and follow-up session 1 week later, Jamie correctly identified 10 sounds/min.

Figure 10 displays Jamie's see/say letter sounds rate with the letter set (f, e, a, s, t, i) taught using the combined procedures. After correctly identifying 0 sounds/min in baseline timings, Jamie completed the stimulus shaping procedure in 651 trials including 138 errors. Jamie's stated 8 correct sounds/min during the first see/say session, with performance peaking at 18 correct sounds/min across training. During the follow-up session, Jamie correctly said 4 sounds/min.

Figures 11 through 13 show David, April, and Jamie's hear/point letter sounds performance across the stimulus shaping procedure. The participants completed the steps in 16, 39, and 41 sessions, respectively.

Total training duration is depicted in Figure 14. Jamie's letters taught using only the see/say fluency methods reached the rate mentioned above in 191 min of teaching time. However, the letter set taught using the combined procedures reached the aforementioned rate in 114 min, which is 60% of the time required using only the fluency-based procedures. Training durations for April's letters were 143 and 64 min for
letters taught using only the fluency-based and combined procedures, respectively.

David’s training duration for letters taught using only the see/say fluency methods was 119 min of teaching time. However, the letter set taught using the combined procedures reached a comparable rate in 80 min, which is 67% of the time required using only the fluency-based procedures.

Figure 15 shows that all participants completed fewer trials with the letter set taught with the combined procedures than with fluency alone. Jamie completed 3459 trials with the fluency only trials and completed 1061 trials with the combined procedures. April completed 2524 trials with the fluency only trials, while completing only 647 trials with the combined procedures (Figure 12). David completed 2452 trials using the fluency only trials and completed 1562 trials, which is 37% fewer trials, with the combined procedures.

Lastly, Figure 16 displays the percent of errors emitted by participants in each procedure. 53% of Jamie’s trials with the letter set taught with only the fluency-based procedures were errors, compared to 32% of trials with the combined procedures. For April, 52% trials with the letter set taught with only the fluency based procedures were errors, compared to 27% of trials with the combined procedures. Of the total number of trials, 24% of David’s trials with the letter set taught with the fluency-based procedures were errors and 12% of trials with the combined procedures.

Table 1 shows that Jamie, April, and David chose to start with the letter set taught with the combined procedures 90%, 83%, and 76% of sessions, respectively.
DISCUSSION

The results of this research indicate that combining stimulus shaping and fluency-based procedures may decrease the number of errors and duration of time to teach letter sounds to typically-developing preschoolers. The impact of this finding is multiplied when the possibility of applying this technology in a classroom is considered. Due to time constraints (i.e., end of the school year), sessions were discontinued prior to the participants’ performance meeting the fluency criterion of 60 sounds/min across 3 consecutive sessions. In order to make a clean comparison of the two letter sets, Jamie’s sessions were stopped at a point when the rate of each letter set was close to equal. April’s letter sound rates were not at comparable levels by the end of the study. Because two participants’ performance did not approach fluent levels, interpreting the results requires some caution. Despite varying performance across the participants, though, there were several commonalities.

Acquisition

First, average teaching time/trial in each procedure was approximately equal for each participant. However, the distinct advantage of combining the procedures is highlighted when examining the number of trials and errors to reach comparable see/say letter sound rates. David and Jamie’s responses reached comparable rates with the combined procedures in at least 1/3 fewer trials than with the fluency procedures alone.

Second, with the letter set taught using the combined procedures, the errors participants emitted were at a much lower percentage than the letter set taught with the fluency-based procedures. Errors ranged from 12% to 32% of trials using the combined
procedures and 24% to 54% of trials with only fluency-based procedures.

Third, all participants chose to begin with the letter set taught with the combined procedures a range of 76% to 90% of sessions, which is similar to participants' performance in Doucette's (2007) study. Initially, this may have been due to the use of pictures that were both familiar to the participants and, therefore, may have functioned as conditioned reinforcers. Additionally, with this letter set the number of errors was lower. So, participants may have chosen the letter set based on increased probability and history of success (Griffiths & Griffiths, 1976).

In reviewing days preceding participants’ choices to begin with the letter set taught with only fluency-based procedures, only one possible explanation is evident: Both April and Jamie chose to start with the flashcards several times when the intraverbal mediation training was conducted instead of the stimulus shaping pictures the preceding day. This suggests that the intraverbal mediation procedure was less preferred than the flashcards. No discernable pattern or explanation was detected in David’s choices to start with the second letter set.

Only one participant, David, completed the fluency-based procedures without reducing the number of stimuli. Both April and Jamie emitted such high rates of errors and low acquisition that the number of letters was reduced to increase the probability of their success.

In addition, April and Jamie required an adjustment to the stimulus shaping procedures with the addition of the intraverbal mediation training. The ability to mediate is a required skill to complete the procedure with few errors and these participants did not exhibit this skill independently. Once the mediating response was learned,
participants were able to complete the stimulus shaping steps, as also reported by Doucette (2007).

As Doucette (2007) also found, participants younger than 5- years required the addition of the intraverbal mediation procedure and their performance did not reach fluency by the end of the study. Although the reason for this is not entirely clear, there may be some developmental milestones that are necessary prerequisites to increase the probability of success in a program like this one. Assessment of prerequisite skills of all children, particularly those younger than 5 years, may reveal the skills that must be learned before introducing the present program. It is possible that younger children may not readily attend to the critical features of the stimuli, making letters that look or sound similar to others (such as those used in this study) particularly difficult to discriminate. Gilbert (1978) noted that similar components may compete with each other and can result in a higher rate of errors, particularly with beginning readers. Additionally, younger participants may not have the necessary attending skills, such as sitting still at the table or attention to the learning materials, and that may also adversely affect their rate of learning.

April’s see/say letter sounds rates did not reach comparable levels or meet the fluency criterion. Several variables may account for this. First, April required a longer period of time to complete the stimulus shaping procedures, leaving just one session in which to teach the same letter set with the see/say fluency-based procedure. April was also absent 11 of the 54 days the study was conducted not including the 16 regular school day (Monday to Friday) sessions that were not run due to reasons such as holidays and school events. Therefore, the frequent breaks in instruction may have
negatively impacted this participant’s learning and retention of the letter sounds. Lastly, the procedures may not have been optimal to help her acquire the letter sounds. Ways to improve the procedures are discussed in more detail below.

Retention

Although David’s see/say letter sound rate did not quite meet the fluency criterion of 60 sounds/min across 3 consecutive sessions set for this study, his rate with both letter sets did meet or exceed that rate during several nonconsecutive sessions. David’s rates decreased slightly to 50 correct sounds/min in the letter set taught with the combined procedures and 40 sounds/min in the set taught with the fluency-based procedures during the test for retention. It may be important to note, though, that David’s throat was sore that day and he struggled to say the letter sounds more during the second timing which was the letter set taught with the fluency-based procedures. In better health, David’s rates may have been closer to 60 correct sounds/min.

Due to time restrictions (i.e., the end of the school year), it was only possible to test for Jamie’s retention of the letter sounds 1 week later. One of Jamie’s see/say letter sound rates in the combined set (f, e, a, s, t, i) decreased during the retention test from 10 to 4 correct sounds/min. However, Jamie’s see/say letter sounds rates in the fluency only set (d, o, u, p, v, b) were the same as the final session 1 week earlier with 10 correct sounds/min. Jamie’s rates had reached only as high as 18 and 22 correct sounds/min, which is less than half of the established criterion. Since retention of the letter sounds is more likely if the behavior is fluent (Binder et al., 2002), it is possible that the rates of both letter sets would have been lower if tested several weeks later.
Implications for Future Research and Application

Although this early research is promising, additional studies need to be conducted to confirm the benefits of combining stimulus shaping and fluency-based procedures to teach letter sounds. There are a few adjustments that may increase the effectiveness and efficiency of components of these teaching procedures.

First and foremost, the results of this study will have little influence until stimulus shaping materials are available to the public. Until that time, educators may decide that the amount of resources required to make their own materials outweighs the benefits. Despite the possible advantages of combining the procedures, teachers may not want to take the time, have adequate drawing ability to easily produce the picture sheets, or the analytic skills to ensure their effectiveness. With other commercially available products that claim to teach children letter sounds in an effective and entertaining way, teachers are not likely to pursue this method.

Another important point is that only one participant’s rate neared the fluency criterion. Therefore, there is no comparison available to rule out the possibility that one letter set is more easily discriminated than the other and therefore requires less time to learn. Future studies should account for this by counterbalancing teaching procedures across letter sets and attempt to avoid time restrictions to determine whether one set of letter sounds tends to be acquired in a shorter amount of time than the other. Doing so will help clarify the role the stimulus shaping procedure played in the decreased teaching duration.

Although these procedures were not optimal, in terms of reduced errors and quick acquisition, for the two younger participants, it should not necessarily be taken as
discouragement of including children of the same ages in a similar study. Modifications to the current procedures may make it more likely that the participants would learn the letter sounds quicker and with fewer errors.

For example, it may be beneficial to teach the intraverbal mediation from the beginning of the stimulus shaping procedure by prompting the student, if he/she does not do so independently, to say the picture name when he/she points to the picture. Mediation may reduce the number of errors and duration of teaching time required to complete the stimulus shaping sequence (Gilbert, 1978). Although the participants in the present study occasionally stated the name of the picture while pointing, there were no specific contingencies in place to capture that behavior or evaluate its acquisition and effects.

It is important to note that mediation resulted in additional errors when see/say instruction began. All participants initially stated the name of the picture rather than the letter sound when first presented with the flashcard displaying the letter. David, who did not undergo intraverbal mediation training, only emitted a few of this type of error. Both April and Jamie required multiple prompts to say the correct letter sound rather than the picture name. Therefore, evaluation of ways to minimize this interference may be helpful to reduce the number of errors.

The stimulus shaping procedures did not meet Lancioni and Smeet’s (1986) definition of errorless learning, performance with fewer than 10% of errors, with any participant. However, David’s performance was just 2 errors over the 17 possible to meet that criterion. Additional evaluation of ways to increase the probability of errorless learning with these procedures with all students is needed. Possible areas of analysis
include repeating steps and changing the topography of the stimuli more gradually.

Repeating the final step of the stimulus shaping procedures in which the letters were in
their final form may also increase the probability the participants will accurately state the sound when presented in see/say trials.

There are several see/say fluency procedure changes that may be beneficial. First, increasing the number of practice opportunities during each session, whether before or between timings, may decrease the number of sessions required. However, the duration of each session would increase. Additionally, different error correction techniques may be helpful. For example, Worsdell et al. (2005) found that participants learned to discriminate more sight words when required to repeat the correct word multiple times, as opposed to one time, in the presence of the stimulus after emitting an incorrect response. However, before implementing any error correction procedure, experimenters must take into consideration that error correction may be aversive and function as punishment. Rodgers and Iwata (1991) found that repeated trials following errors had a negative reinforcement as well as increased stimulus control component.

In future studies, if the number of letters is reduced, as with April and Jamie, meeting a rate requirement in addition to the accuracy requirement and/or maintaining the accuracy requirement across several days before adding letters may omit the need to reduce the student’s goals. It may also be beneficial to start with fewer than 6 stimuli rather than reducing the number following a number of errors. Modifying the fluency-based procedure may reduce the errors and provide a different and, perhaps, clearer picture of the benefits of combining a see/say fluency-based procedure with an errorless hear/point stimulus shaping procedure.
The reduced duration and errors to reach comparable letter sound rates with the letter set taught with the combined procedures may indicate the need to reach an accuracy criterion before conducting timings. Future studies can evaluate the effects on teaching duration and number of errors emitted to teach letter sounds to fluency when timings are conducted every teaching session or not until after an accuracy criterion is met.

One additional point of examination is that participants were able to identify letter sounds learned with the combined procedures in the hear/point learning channel and, to varying degrees, the see/say learning channel. Generalization to the hear/point learning channel with the letter sounds taught with only the fluency-based instructions was not assessed. Future studies can assess for generalization across learning channels to determine whether participants acquire only the see/say or both the see/say and hear/point discriminations.

Conclusion

In conclusion, despite differences in performance across participants, the results indicate that combining stimulus shaping with fluency-based procedures may reduce the overall duration to fluent letter sound performance. In addition, fewer errors were emitted when the procedures were combined. Combining these procedures allowed many advantages of each technique to be extracted and applied to teaching letter sounds while the disadvantages were minimized. With reduced teaching time and errors, teachers can more efficiently build the reading repertoires of students, allowing more time to develop more complex skills.
Table 1

*Participant Procedure Preference*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Fluency</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jamie</td>
<td>10%</td>
<td>90%</td>
</tr>
<tr>
<td>April</td>
<td>17%</td>
<td>83%</td>
</tr>
<tr>
<td>David</td>
<td>24%</td>
<td>76%</td>
</tr>
</tbody>
</table>

Table 2

*Total Trials and Errors, Including Intraverbal Mediation Training, During the Stimulus Shaping Procedure*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Trials</th>
<th>Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jamie</td>
<td>651</td>
<td>138</td>
</tr>
<tr>
<td>April</td>
<td>578</td>
<td>108</td>
</tr>
<tr>
<td>David</td>
<td>180</td>
<td>19</td>
</tr>
</tbody>
</table>
Figure 1. Sample pretraining stimuli.
Figure 2. Final stimulus shaping and see/say stimuli.
Figure 3. Initial stimulus shaping training stimuli. The upper 6 stimuli correspond with letters upbvod and the lower 6 stimuli correspond with the letters easfit.
Figure 4. Sample sequence of stimulus shaping stimuli across training steps. The first column represents pictures presented in Steps 1 through 7. The last three columns represent pictures in Steps 8 and 8.a., 9 and 9.a., and 10, respectively.
Figure 5. David’s see/say letter sounds (d, o, u, p, v, b).
Figure 6. David’s see/say letter sounds (f, e, a, s, t, i). The gap in time between baseline (BL) and the first training session is when the stimulus shaping procedure was implemented.
Figure 7. April’s see/say letter sounds (d, o, u, p, v, b). The gap in time between baseline (BL) and the first training session is when the stimulus shaping procedure was implemented.
Figure 8. April's see/say letter sounds (f, e, a, s, t, i).
Figure 9. Jamie’s see/say letter sounds (d, o, u, p, v, b).
Figure 10. Jamie’s see/say letter sounds (f, e, a, s, t, i). The gap in time between baseline (BL) and the first training session is when the stimulus shaping procedure was implemented.
Figure 11. David’s hear/point letter sounds across the stimulus shaping procedure.
Figure 12. April’s hear/point letter sounds across the stimulus shaping procedure.
Figure 13. Jamie’s hear/point letter sounds across the stimulus shaping procedure.
Figure 14. Total training duration.
Figure 15. Total trials.
Figure 16. Percent errors.


Etzel, B. C., & LeBlanc, J. M. (1979). The simplest treatment alternative: The law of parsimony applied to choosing appropriate instructional control and errorless-


