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CERTIFICATE OF APPROVAL

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This is to certify that the Master's Thesis of

RUSSELL GERARD BOYCE

with a major in Speech-Language Pathology has been approved by
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Examining Committee:

Major Professor: Elizabeth Kaplon, Ph.D.

Member: Robert Dedrick, Ph.D.

Member: Mark Witkind, Ed.M.

AN INVESTIGATION OF DELAYED AUDITORY FEEDBACK IN SPEECH RATE CONTROL

by

RUSSELL GERARD BOYCE

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science
Department of Communication Sciences and Disorders
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April 1999

Major Professor: Elizabeth Kaplon, Ph.D.

Dedication

I would like to dedicate this thesis to my parents, Allen and Michele Boyce. Parents who instill and nurture a love for education make anything possible.

Acknowledgments

Many people helped make this project possible. My committee heads the list. Dr. Elizabeth Kaplon allowed me the freedom to follow a dream. She let me discover the real world logistics of research, which in retrospect, is what beginning research is all about. Dr. Dedrick was an invaluable member of the team for his expertise in research and measurement, and for his viewpoint from outside the Communication Sciences and Disorders department. Mr. Witkind not only brought his knowledge of fluency disorders to the team, but was also always available to respond to brewing ideas and concerns during the project. Many extremely helpful people within the public school system must remain unnamed because of participant privacy issues. They range from classroom teachers, to speech language pathologists, to administrators at every level. Without their help, this thesis would not have been possible. A special thanks to my brother, Steven Boyce, for his help in developing the software that made this research go more smoothly than I could have dreamed. I also wish to thank Elizabeth Collins, a colleague who helped determine the reliability of speech duration measures. Finally, I must thank my wife Carol, and my son Parker, for allowing me the time away that was necessary to bring this project to completion, and constantly reminding me of what is really important.

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An Abstract

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Many stuttering therapy programs include a component that trains reduced speech rate because of its known stuttering reduction effect. There has been abundant research linking the reduction of speech rate with the reduction of stuttering frequency, but very little concerning speech rate training methodology itself. Most therapy programs which train speech rate utilize periodic visual feedback as the speech rate training method. This takes the general form of clients receiving periodic visual reinforcement of their speech rates after reading or conversational speech, in an effort to train them to speak at a reduced speech rate. The study of delayed auditory feedback (DAF) and its ability to create fluent speech was popular among researchers and therapists in the 1960's through the early 1980's. A review of the literature concerning DAF and fluency enhancement suggests that DAF might be an effective rate control training device. The main purpose of this study was to attempt to determine if DAF might be a more effective rate control training device than periodic visual feedback in people who stutter.

A single subject design was used to test participant ability to control speech rate consistently after no training, DAF training, and periodic visual feedback training. Six participants took part in this study, with the speech rate results of five used in the analysis of speech rate control ability. One participant was unable to complete all portions of the study, and his speech rate data were omitted. Participant speech rates were analyzed for speech rate control ability based on the mean and standard deviation of speech rates, a visual inspection

of speech rate trends, and proximity to a pre-determined speech rate range criterion.

Results of the study were unable to support either DAF or periodic visual feedback as the more effective speech rate training method across all people who stutter. They did suggest that both DAF and periodic visual feedback can be effective as speech rate training methods. More importantly, this study suggests that several other variables, possibly connected to individual preference or predisposition, may be instrumental in the ability to control speech rate after training.

Abstract Approved: ____

Major Professor: Elizabeth Kaplon, Ph.D.
Professor, Department of Communication Sciences and Disorders

Date Approved: ____________________

Chapter I.

Introduction and Literature Review

Research Question and Operational Definitions

Slowed speech rate has been shown to be an effective means of reducing stuttering frequency (Andrews, Howie, Dozsa, & Guitar, 1982). The use of a slowed speech rate is not a new technique in stuttering therapy, in fact, Israel Goldiamond (1965) coined the phrase “prolonged speech” during his research. He incorporated delayed auditory feedback (DAF) into his work by having his participants prolong syllables while speaking under DAF. This was shown to be an extremely effective stuttering reduction technique (Goldiamond, 1965). Variations of the prolonged speech method are still in use in North America, Europe, and Australia (Ingham, 1984). With the popularity of slowed speech rate as an integral part of stuttering therapy, it is surprising that little research has been devoted to the effectiveness of different rate control techniques.

Several techniques of speech rate control are discussed in the literature. They include rate control through manipulation of the speed of material read (Goldiamond, 1962, 1965); on-line, periodic feedback of speech rate while participants attempt to maintain a target rate (Ingham, Martin, & Kuhl, 1974; Ingham & Packman, 1977; Sacco, 1996; Webster, 1972); and DAF as a rate control method, secondary to fluency management (Curlee & Perkins, 1969, 1973; Perkins, 1973; Perkins, Rudas, Johnson, Michael, & Curlee, 1974; Ryan, 1974; Shames & Florance, 1980). Although all of the above mentioned rate control methods are effective in their primary purpose of stuttering reduction, an investigation of the effectiveness of the rate control methods themselves appears to be a fruitful area for research. Specifically, does the use of DAF to systematically train reduced rate of speech produce more accurate rate control than periodic feedback of speech rate training in individuals who stutter? Periodic feedback of rate can be defined as the intermittent, visual, on-line reinforcement of a target speech rate, while DAF is a phenomenon created by delaying verbal output by a prescribed number of milliseconds (ms) before it reaches the ears. Speech rate can be defined as the number of words or syllables spoken per minute (wpm or spm). Stuttering can be defined as involuntary, audible or silent, repetitions or prolongations in the utterance of a short speech element, namely: sounds, syllables, and words of one syllable (Wingate, 1964). According to Cordes and Ingham (1994), Wingate's definition of stuttering is the most widely cited behavioral definition of stuttering. The theoretical construct and dependent variable under investigation in this research is speech rate control, as defined by the ability of participants to consistently produce a prescribed rate of speech. The independent variable being manipulated is method of speech rate training.

Rate Control Training Methodology

In periodic feedback of speech rate, the participant controls the speech rate that is produced, with an external system that provides feedback at pre-determined intervals (Sacco, 1996; Webster, 1972). Webster realized early in his fluency shaping program at Hollins College in Virginia that clients were having difficulty discriminating and controlling their own speech rate. He added a component to his program in which clients had to distinguish between two speech rates and produce either one when signaled. One rate was approximately 75 words per minute (wpm) and the other 110 wpm. The feedback in this case was provided online as the client attempted the prescribed speech rates. Computer software called CORE, or computation of rate exercises (Sacco, 1998), was incorporated into the speech rate training portion of Sacco's fluency program. Participants spent several days reading sentences and paragraphs aloud while being visually reinforced by CORE on speech rates as they honed in on target rates of 120, 130, 140, and 150 wpm. Prior to and after reading a sentence or paragraph, the client clicked a mouse button, which generated a speech rate report. The report was displayed, giving the client periodic visual feedback of speech rate. This form of rate training allowed the participant an internal locus of speech control with an external feedback mechanism that provided rate information on a periodic basis.

Another form of rate training called continuous feedback was used by Goldiamond (1965). In contrast to periodic feedback, Goldiamond's rate procedure forced the participants into a rate of speech that was primarily controlled by a machine called a PerceptoScope. The PerceptoScope, a 16 millimeter film strip, projected approximately three words on a screen at a prescribed rate. The client had to read the words as they were projected and usually did not have control of the presented material. Although rate could be controlled either by participant or researcher, there were rate control aspects of the program that required researcher control of rate (Goldiamond, 1962, 1965). Considering the difficulties of those who stutter in initiating and maintaining speech flow, this author thinks that the continuous, forced speech rate training method is ill suited as a training technique in the early stages of fluency therapy. After significant gains in fluency have been achieved, this method may be beneficial as a rate trainer.

A third form of rate training described in the literature is the use of DAF to mechanically aid reduction in speech rate. The primary use of DAF in speech therapy has been in the treatment of stuttering, but several researchers, including Perkins (1973) recognized that DAF delay levels corresponded accurately with speech rates produced under delay. This form of speech rate feedback provided an internal locus of control for the participant, since the speech act was initiated by the client and then guided by the pacing properties of the DAF. Perkins described a DAF fluency treatment plan that included a goal to establish normal speech rate. The procedure involved a three step process. Initially, the client was placed under 200 ms of delay which corresponded to 45-60 wpm. As the client read, instructions were given to prolong the syllables in each word to overcome the DAF echo effect.

Essentially, the client was instructed to match what was being produced orally in the microphone with what was heard in the headphones to compensate for the DAF echo. The next step was a reduction in DAF delay to 150 ms or 90-120 wpm. The final step was a reduction to 100 or 50 ms with a corresponding rate of 100-150 wpm. This reduced speech rate, along with fluency improvement from the rest of the program, were then transferred to speech without DAF.

Rate Reduction and its Effect on Fluency

Rate reduction and its effect on fluency has been studied by several researchers in the past. Ingham et al. (1974) conducted a quasi-experiment in which three participants, all adults who stuttered, were required to speak at their habitual speech rate initially in order to calculate a mean speech rate. In the treatment phases, participants were required to speak at 50% above and 50% below their mean speech rates. No information was supplied concerning the age, gender, or stuttering severity of the participants. The method used for rate control was periodic visual feedback. The experimental apparatus consisted of a remotely controlled bank of five vertical lights that gave the participants feedback on speech rate every minute. Speech rate and stuttering frequency were calculated on-line by the researchers. The goal of the treatment stages was for participants to keep the green light lit, corresponding to ± 10% of target rate, for 20 consecutive minutes. Stages lasted 300 minutes total or when the participant was able to keep the green light lit for 20 consecutive minutes. The total number of sessions per participant was approximately 20, depending on how quickly they were able to achieve the specified speech rate criterion. Results indicated that two of the three participants reduced stuttering frequency by approximately 50% in the 50% below base rate condition, while the remaining participant had similar stuttering percentages for all three treatment conditions. Interrater reliability of stuttering counts was provided by a third observer who rated eight randomly selected stages from each participant. Pearson product moment correlations for the three participants were .93, .96, and .95. While evidence in this study was not conclusive for the effect of reduced rate on stuttering, additional research has provided support for the effectiveness of slowed speech rate on stuttering amelioration (Andrews et al., 1982; Ingham & Packman, 1977). In addition, the researchers did not give specific information on how long it took the participants to obtain the designated speech rate criteria, but it can be assumed that since all three progressed from base rate to 50% above and 50% below mean speech rate conditions, each was able to successfully control speech rate within the ± 10% of target rate criteria.

In a study similar to the one above, Ingham and Packman (1977) used the same rate control device with a slightly different training model in a single participant design. The participant was a 42 year old woman who stuttered mildly. In addition to stuttering frequency, the researchers also measured speech rate control. In one component of the study, speech rate manipulation and contingency management through electronic wrist stimulation were linked in an ABAB design. Target speech rate was identified not as a mean, but by testing the full range of speech rates within the participant's normal range, and identifying the one which produced the lowest percentage of syllables stuttered per minute (ssm). It is interesting to note that the participant's best speech rate for decreased stuttering percentage was the second to lowest, 150-170 syllables per minute (spm). More importantly for this author's research, the participant was able to keep her speech rate within the target range for most of the sessions. No mean or standard deviation of speech rates were reported. Interrater reliability for spm was obtained by having a student speech language pathologist independently assess 10% of laboratory sessions. The Pearson product moment correlation (r) was .96. Speech rate control, at least in the laboratory, was shown to be a viable treatment component in stuttering therapy. Conversely, when the participant went outside the clinic and made self-monitored judgments of speech rate, measurements were higher and less consistent than in the clinic. The authors attempted to explain this inconsistency by questioning the reliability and validity of the participant's self-monitored speech rates.

DAF, Prolonged Speech, and Rate Control

Since its earliest use by Goldiamond (1965), DAF has been used primarily for its fluency enhancing effect on the speech of persons who stutter. One contribution by Goldiamond, which is indispensable for this author's research, is his explanation of participants' reactions under DAF. He explained that the DAF effect of having one's speech echoed back caused people to do one of four things to normalize their initial speech disruption under DAF. First, participants could slow their speech by prolonging syllables until the output coming from the mouth equaled the delayed input reaching the ears. Goldiamond identified this pattern in his research as the one most easily and consistently trained and monitored by the researcher. The other reactions he identified included voice lowering, increasing laryngeal muscular tension, and tuning out the delay. This is very important in considering the consistent effect of DAF on participants as it relates to speech rate control. If participants are not trained how to respond to DAF, their chosen response may not produce a consistent speech rate. Goldiamond identified prolonged speech as a slowing and stabilizing method to overcome DAF, but he may not have fully recognized its ability to control speech rate. He initially used DAF as a punishment contingency during experimentation, and later discovered by accident that DAF promoted fluent speech. From there, DAF was used to shape fluent speech, and rate was manipulated using a projection device that controlled the words per minute that a participant read. It wasn't until later that researchers began to recognize a correspondence between DAF delay rates and speaking rates. Currently, the main focus of DAF research remains centered on the improvement of fluency.

In research and treatment conducted by Curlee and Perkins (1969, 1973), Perkins (1973), Perkins et al. (1974), Ryan (1974), and Shames and Florance (1980), speech rate was identified as being the by-product of different delay intervals. In each of these studies or programs, while DAF was being administered, the participants were told to prolong their speech in order to overcome the DAF effect. This produced a consistently reduced speech rate for each delay interval. Although this effect was recognized at some level by each of these researchers, the primary use of DAF was for its stuttering reduction properties. All of the above researchers developed stuttering programs very similar in design to the one originally described by Goldiamond (1965). All programs used DAF to promote fluent speech with participants prolonging their speech in order to overcome DAF effects. In addition, all of the programs required participants to go from higher DAF levels, usually 200-250 ms, which promoted slower speaking rates to lower DAF levels of 50-100 ms in 50 ms incremental stages. The lowest DAF levels produced near normal speech rates. For a participant to progress through these DAF treatment stages, a criterion of decreased stuttered words or syllables per minute had to be achieved for a designated period of time, approximately 30 minutes. Once all stages had been completed, the client was taken off DAF and the prolonged speech was shaped into more normal sounding speech.

Shames and Florance (1980) described their DAF delay reduction program from 250 ms down to 0 ms in 50 ms increments in relation to the speech rate that was approximated at each delay interval. They stated that a 250 ms delay corresponded to approximately 30 words per minute (wpm), a 200 ms delay to 45 wpm, a 150 ms delay to 60 wpm, a 100 ms delay to 75 wpm, and a 50 ms delay to 90 wpm. This 250 ms rate correspondence was confirmed by Curlee and Perkins (1969) at 30-35 wpm, and Perkins (1973), and Perkins et al. (1974) at 30 wpm. Further evidence of the correspondence between DAF level and rate of speech was reported by Ham, Fucci, and Cantrell (1984). In their study, 10 female participants aged 10 to 14 years old read the same passage, first on a conventional research DAF instrument and then on a portable DAF unit. The study was designed to determine the effectiveness of the two units in producing similar speech rates. Results of the study indicated significant Pearson product moment correlations (r) between portable and conventional DAF unit readings .80, and between readings with the same unit, .80 and .62 for portable and conventional units, respectively. This is strong evidence for the use of DAF as a means of training speech rate.

Another way of exploring the literature concerning DAF and corresponding rate control is to look at the stuttering research that has incorporated DAF but has not instructed its participants to prolong their speech under the DAF delay. This created a situation where participants reacted differently and less consistently under DAF. One of the earliest studies that investigated DAF and its effect on stuttering was the work of James N. Neelley, under the supervision of Wendell Johnson, at the University of Iowa in the late 1950's and early 1960's. As part of his doctoral dissertation, Neelley investigated DAF with 23 adult males who stuttered, ranging in age from 17 to 36 years old, and 23 adult males who did not stutter, ranging in age from 19 to 32 years old. The study was designed to investigate the frequency of stuttering, the adaptation of stuttering, or the decrease of stuttered words from one oral reading to the next, and the consistency of stuttering, or the tendency to make the same errors from one reading to the next. It also looked at correct word rate (CWR), which Neelley defined as the number of words spoken per second without error, divided by the time in seconds. This measure successfully controlled for the confounding (slowing) effect of stuttered words in speech rate measurement. Participants read a 100 word passage under no auditory feedback, and then read the same passage 24 hours later under 140 ms of DAF. No special instructions were given to participants concerning the way they should read the passage. The participants were not instructed or trained to prolong their speech under DAF. The results of the experiment indicated a wide variance in CWR under 140 ms of DAF. One participant had a CWR of 1.86 under DAF, and another participant had a CWR of .28 under DAF. These scores indicated a consistent speech rate was not maintained at the DAF level under investigation. This experiment took place before the work of Goldiamond (1965), but Neelley had an inkling that perhaps his participants were reacting differently from each other under DAF, as Goldiamond later asserted. As Neelley discussed CWR in his research, he stated the CWR variance invited further study since the data suggested that participants' reactions under DAF were either unpredictable, or the result of differing participant responses under delay (Neelley, 1961).

The lack of consistency in DAF response relative to speech rate, created when syllable prolongation is not utilized by participants, was also demonstrated in recent research by Kalinowski, Stuart, Sark, and Armson (1996). Fourteen participants who stuttered, aged 18 to 52 years old, read eight paragraphs of 300 syllables, four at normal speech rate, and four at a fast speech rate. Each reading occurred under one of four DAF conditions, 25, 50, or 75 ms DAF, or without DAF. It was found that there was no relationship between syllable rate and level of DAF under these speaking conditions. This finding of inconsistent rate was no surprise to the researchers, as they had stated in their introduction that they felt there was no single, invariant reaction to DAF, including slowing of speech rate. Their assumptions mirror those of Goldiamond (1965) who wrote about DAF reaction variability more than 30 years ago.

DAF and Prosthetic Rate Control

Although DAF has not been used as a rate control training method without fluency as a final goal, the literature does describe its use as a prosthetic means of continuous rate control for individuals who suffer from a particular form of Parkinson's disease. This form of dysarthria, caused by a lack or inhibition of dopamine in the basal ganglia, is usually accompanied by bradykinesia, or an abnormal slowing in initiation of movement. Darley, Aronson, and Brown (1975) identified a subset of patients with Parkinson's disease who displayed a rapid, unintelligible speech pattern they termed accelerating speech. This pattern of speech was identified in 13% of their patients. In a study conducted by Hanson and Metter (1983) two patients with accelerating speech were treated with DAF in an effort to reduce speech rate. One patient, a 58 year old male, was characterized with mild Parkinson's disease and had an average speech rate of approximately 250 words per minute (wpm). The second patient, a 56 year old female, was characterized as moderate to severe, and had an average speech rate of 183 wpm. Each participant was placed under 150 ms DAF by wearing a portable unit daily for a three month period. During this time, each participant read the Grandfather Passage four times while being audio taped for later speech rate analysis. The male client averaged 166 wpm under DAF, and the female client averaged 137.25 wpm. The results indicated the continuous DAF treatment produced a substantial improvement in speech rate, especially for the male client. In addition, vocal intensity and intelligibility improved for both participants. The researchers stated that no carryover of speech rate improvement occurred once the participants spoke without DAF. There are a few possible explanations for this phenomenon. First, the researchers did not institute any formal rate training program in their study, allowing the participants to speak under delay continuously, without instruction or attempts to transfer their slowed speaking rates to non altered feedback conditions. Second, the accelerating speech produced by Parkinson's disease is a result of neurological impairment, and possibly not influenced by DAF in carryover speech when the delay is not present. It is important to note that this possibility is not necessarily a hindrance to the use of DAF in training reduced speech rate with persons who stutter. Although a neurological basis for stuttering is currently one of many possible etiologies; to date, the disorder of stuttering does not have a defined neurological deficiency with a causal relationship to abnormally fast speech rate.

Research Hypothesis and Rationale

In researching the alternative methods of periodic feedback of speech rate and DAF as rate control devices, it appears to this researcher that DAF may be the more powerful method of training speech rate control. In considering both rate training procedures, it is apparent that DAF provides a more continuous feedback mechanism than does periodic visual reinforcement. In DAF training, participants receive rate feedback stimulus throughout the entire utterance, while periodic visual feedback provides only intermittent measures of speech rate. This observation lead to a research hypothesis concerning rate control training that states that the use of DAF to systematically train reduced rate of speech may produce more accurate rate control than periodic feedback of speech rate training in individuals who stutter.

This research hypothesis suggests a novel use for DAF in stuttering therapy. If DAF proves to be an effective rate control trainer, its known fluency enhancing effects could allow clinicians and clients to focus on rate control at an earlier stage in therapy, since the rate retarding effects of stuttering would be lessened by DAF's fluency enhancement. As mentioned earlier, DAF has been primarily used as a tool to produce fluent speech. Its relationship to rate control has been largely overlooked, possibly because of the difficulty researchers and clinicians have encountered in transferring DAF produced fluent speech from the laboratory to everyday speaking situations. The cause for this lack of transfer may be the reliance on DAF as the only element used for fluency enhancement in a stuttering therapy program. This hypothesis is supported by

Culatta and Goldberg (1995); who described components that were necessary for a successful fluency management program. Their acronym PROLAM-GM encompassed many different fluency enhancing elements within one treatment methodology. They included physiological adjustment of the speech mechanism, operant controls, attitude, and rate of speech manipulation.

Research by Perkins et al. (1974) exemplified the danger of relying on a single treatment element in fluency therapy. Their study involved two treatment methods, group one using DAF as a rate driven fluency enhancer, and group two, using DAF in the same manner, but also incorporating elements of breathstream management, phrasing, and prosody. Final results of treatment indicated that both methods reduced stuttering frequency significantly ($p < .01$). Six months after treatment, group one had gone from 2.64% syllables stuttered (ss) to 8.44% ss, while group two had gone from 1.04% ss to 1.73% ss. This was a significant increase for group one ($p < .05$). These results indicated that a treatment methodology that incorporated more elements than just DAF, and its subsequent effect on rate, was more effective in maintaining fluency over time. The treatment of stuttering with a multi-faceted approach could allow clinicians and researchers to view DAF differently, and perhaps help create a new identity for DAF as a rate management component of an overall fluency enhancement program.

Chapter II.

Methods

Participants

The sample for this research was drawn from individuals who stutter from two West Central, Florida County School Systems. Initially, a sample size of between 20 to 30 children, aged 15 to 18 years old was sought. Difficulty in obtaining the required number of participants resulted in the need to modify the experimental procedure, as is discussed in the procedure section on page 20. A total of six participants were recruited, aged 15 to 18 years old. Participants below the age of 15 were excluded, as components of the experimental design, including time restraints, cognitive ability, and maturity level made it difficult for those below age 15 to understand and readily implement prolonged speech under delayed auditory feedback (DAF). The sample included one female and five males, although the results for one male were invalidated when he was unable to complete all portions of the experiment. Table 1 summarizes demographic and pertinent screening information for all participants.

Table 1

Participant Demographic and Screening Information

Participant	Sex*	Age	Race**	Stuttering Severity	Initial Screening Speech Rate
1	M	15	C	Mild	261 spm
2	M	16	C	Mild	192 spm
3	M	17	A	Severe	***
4	M	18	C	Moderate	235 spm
5	M	17	C	Moderate	229 spm
6	F	16	A	Moderate	244 spm

*Sex: M= Male, F= Female
**Race: C= Caucasian, A= African American
***Participant 3 did not complete the study. Speech rate was not analyzed.

Inclusion Criteria

Participants were required to have normal hearing as defined by binaural hearing of equal to or better than 25 decibels (db) Hearing Level (HL) at 1000, 2000, 4000, and 500 Hertz (Hz) (O'brien & Sanspree, 1984). A Belltone Audio Scout portable audiometer calibrated to ANSI 1989 standards was used to present the above frequencies in the order listed starting with the right ear first. Failure to respond to any two or more frequencies resulted in exclusion from the experimental sample. Status as a person who stutters was confirmed through administration of the SSI-3 (Stuttering Severity Instrument-3) (Riley, 1994) at the time of hearing screening. Participants were able to take part in the study if it was determined they were in the very mild to very severe range of stuttering as defined by the frequency, duration, and secondary characteristics measurements of the SSI-3. In addition, participants were required to be able to read at least on a third grade reading level, as the material read during experimentation was written on this level. The main concern was not reading comprehension, but decoding ability. It was felt that a participant who was unable to decode words written on a third grade level might display stuttering-like behaviors while reading and confound the analysis of speech samples. Reading screening was achieved using the graded words in context subtest of The Stieglitz Informal Reading Inventory (Stieglitz, 1997). The subtest measured the ability to decode target words within sentences. Participants were required to pass the third grade level portion of the subtest, which involved successfully decoding 19 of 20 target words within sentences. Finally, participants were screened for the presence of developmental versus neurogenic etiology for their stuttering behaviors. A nine item questionnaire (see Appendix A) was created incorporating the findings of a study on neurogenic stuttering conducted by Market, Montague Jr., Buffalo, and Drummond (1990). All participants were required to answer the questionnaire with no responses indicating neurogenic etiology in order to be included in this research. The above study revealed that of 81 confirmed cases of neurogenic stuttering from throughout the United States, 81.5 % were caused by head trauma, cerebral vascular accident, or the use or abuse of drugs.

Neurogenic forms of stuttering were excluded from this study, because characteristics of neurogenic stuttering differ significantly from those of developmental stuttering. Neurogenic stuttering characteristics include: Stuttering on any syllable in a word, stuttering on small grammatical words, and a lack of secondary features, such as head jerks and eye blinks. This is in direct contrast to developmental stuttering which features stuttering on the first syllable, stuttering on substantive content words, and a defined range of secondary features (Helm, Butler, & Benson, 1978). It was felt that possible differences in reactions to rate control training techniques between neurogenic and developmental stuttering might have introduced an undesirable confounding variable into the study.

Procedures

Instruments

Initial participant screenings for stuttering severity were videotaped with a Chinon model C8-SC70 video recorder with an ATR35S external lavaliere condenser microphone attached approximately six inches from the mouth of each participant. Speech samples were recorded using a Sony model TCM – 59V analog cassette recorder with the same ATR35S external lavaliere condenser microphone. A Dell Latitude XPi P100 SD laptop computer was used to present participants the reading passage called, “A Camping Tale.” The passage is a 197 syllable excerpt written on a third grade level (see Appendix B). Its use for research purposes only was obtained from Steck Vaughn & Company (1990) (see Appendix C). The passage was incorporated into a computer program designed by Steven Boyce called Studder (Boyce, 1998). The program and all of its functions related to the study are fully described in Appendix D. The instrument used to train rate in the DAF treatment condition was the Casa Futura Technologies desktop Fluency System. This is a portable machine weighing 14 ounces. It is capable of supplying feedback delays from 0 ms to 250 ms. Research indicates that a portable DAF unit is as effective as a conventional research model in providing consistent feedback delays and intensities (Craven & Ryan, 1984; Ham et al., 1984).

Experimental Design

As stated previously, the experimental design for this research had to be modified in order to accommodate the smaller than expected sample size obtained. Originally, a true experimental design was envisioned. It was to include two experimental groups and one control group of approximately 10 participants randomly assigned to each condition. When only six participants were recruited, the design had to be modified to a quasi-experiment. Instead of random assignment to condition, each participant received both experimental treatments with a preceding control phase. This was accomplished by utilizing a multiple treatment single subject design.

Once participants were identified and signed a consent form to participate in the research (see Appendix E), they were screened for hearing, reading ability, presence of stuttering, and etiology of stuttering. As part of the stuttering severity evaluation, all participants read the test paragraph as part of the reading portion of the evaluation. They were then tested under the conditions of periodic visual feedback and DAF with at least one week in between experimental conditions to help control for training effect. In addition, the experimental conditions were presented randomly to help control for order effect.

During experimentation, participants were seated in front of the Dell laptop computer with the monitor displaying the 197 syllable test paragraph. All testing took place at the students' high schools, and therefore, the amount of extraneous environmental noise differed from one testing site to another. An analog audiotape recorder and condenser microphone recorded all control and test phase readings for later digitizing and analysis. The experimenter gave all instructions for the procedure from two written scripts, depending on whether the participant was being trained using periodic visual feedback or DAF (see Appendices F and G). Initially, participants were asked to read the test paragraph five times at their normal rate of speech, with no feedback contingency. This occurred for several reasons. First, according to Johnson and Inness (1937), an adaptation effect occurs on multiple readings of the same passage. Their research showed a 48% reduction in stuttering from the first reading to the fifth reading of a 180 word passage. This adaptation effect was also seen in this researcher's experiment. It allowed participants to increase their fluency and be better able to read subsequent trials of the test paragraph. Second, the familiarization of the reading material allowed all participants to become accustomed to the test paragraph in preparation for the subsequent control and training phases.

Control condition. After the reading familiarization phase, and prior to the training phase under periodic visual feedback or DAF, all participants read the test paragraph once as each syllable was highlighted by the Dell laptop computer at a rate of 155 syllables per minute (spm). A speech rate of 155 spm was chosen, because it represented a significant reduction in rate as compared to an average of 170 to 210 spm as reported by Ingham (1984b). A slower than normal target speech rate was desired, because it reduced the chance of a participant having a habitual speech rate that was close to the target rate. If a participant's normal speech rate was similar to the target speech rate used for experimentation, any speech rate control displayed could be considered a reflection of a participant's normal speech rate. The 155 spm speech rate that was produced during the continuous feedback pacing gave participants an idea of the speech rate that should be attempted during the five subsequent test readings under no feedback contingency. The five test readings were recorded, digitized, and analyzed to allow the researcher to determine participants' untrained ability to maintain a consistent lowered speech rate. In addition, the Studder computer program (Boyce, 1998) automatically recorded participants' speech rates, including stuttering moments, for later analysis of training trends.

DAF condition. Once participants completed the control phase, the training phase followed immediately. The order of receiving DAF or periodic visual feedback training first was determined randomly for each participant. During DAF training, participants were placed under 107 ms of DAF using the Casa Futura Technologies portable DAF unit equipped with a boom microphone. A DAF delay of 107 ms was chosen for the delay interval, because according to Perkins (1973), a DAF delay of 50-100 ms corresponded to a speech rate of approximately 100-150 words per minute (wpm). The high end of the DAF range, or 100 ms, produced the slower speech rate of approximately 100 wpm. If wpm are converted to spm with the formula 1.5 syllables for each word (Johnson, Darley, & Spriestersbach, 1963), a DAF delay of 100ms equals approximately 150 spm. This DAF delay/speech rate level was compatible with the 155 spm speech rate that was chosen for the control pacing and periodic visual feedback training readings. It must be noted that the literature concerning correspondence of DAF delay to speech rate contains some variation, and the 155 spm speech rate under 107 ms DAF was considered a good estimate of what participant speech rate would be (Perkins, 1973; Shames and Florance, 1980). The sound level of the DAF unit was placed at the most comfortable level for each participant. Participants were instructed to prolong the syllables in their speech just enough to allow what was being spoken into the boom microphone to match what was being heard in the headset. If speech rate was too rapid for the 107 ms DAF setting, they began to hear an echo effect created by DAF. The object was to find the point where speech rate was just slow enough to maintain the blending of voice output into the boom microphone with voice input into the earphones. Prior to speech rate training under DAF, the researcher monitored approximately five minutes of prolonged speech, via a second headphone jack, to insure that the appropriate prolongation of syllables was occurring. Participants then trained with the test paragraph 20 times under DAF. The final five training readings were recorded for later digitizing and analysis in order to determine the average speech rate of participants under 107 ms DAF. After the 20 DAF training readings, participants read the test paragraph five more times with no feedback contingency and attempted to maintain the speech rates they had trained under DAF. The five test readings after DAF training were recorded, digitized, and analyzed to determine participants' trained ability to maintain a consistent lowered speech rate. The analysis procedure is explained in the data analysis section on page 30. All readings under DAF were also automatically recorded by the Studder computer program (Boyce, 1998) for later analysis of training trends. In addition, the participants were instructed to attempt to maintain normal stress and inflection in their voices throughout the DAF training phase. According to Perkins (1973), and Shames and Florance (1980), DAF has a tendency to produce monotone speech, and it is important to encourage normal prosody during DAF delay. It is felt that speech should remain as natural sounding and feeling as possible in order for it to transfer to normal, non DAF speaking situations. This was an important consideration for this research, since the testing phase occurred without DAF pacing for the DAF treatment group.

Periodic visual feedback condition. Participants were scheduled to undergo the second phase of training one week after the first training condition in order to control for training effect. In the periodic visual feedback condition, participants were required to attempt to speak at a slowed speech rate of 155 spm while reading the test paragraph. This rate was comparable to the 107 ms DAF delay rate in significantly slowing normal speech rate, as compared to normal speech rates of 170-210 spm (Ingham, 1984b). Before and after each of the 20 training readings, participants clicked a start/stop button beneath the test paragraph displayed on the Dell laptop computer. The Studder computer program (Boyce, 1998) calculated and displayed speaking rates, including stuttering moments, each time the test paragraph was read. This gave participants a visual reference of their speech rates. They used this information to either speed up or slow down between test paragraph readings to attain the target speech rate of 155 spm. It was recognized that the visual feedback of speech rate, including stuttering moments, was less accurate and artificially lower than speech rate calculated without stuttering moments, but online calculation of speech rate without stuttering was not possible in this research. After the 20 periodic visual feedback training readings, participants read the test paragraph five more times with no feedback contingency and attempted to maintain the 155 spm target speech rate. The five test readings after periodic visual feedback training were recorded, digitized, and analyzed to determine participants' trained ability to maintain a consistent lowered speech rate. The analysis procedure is explained in the data analysis section on page 30. During the periodic visual feedback phase, the computer program automatically stored speech rates, with stuttering moments, for later analysis of training trends. Table 2 summarizes the experimental procedure and the order of experimental condition for all participants.

Table 2

Experimental Procedure and Participant Order of Condition

1	5 Familiarization readings.
2	1 Continuous feedback reading.
3	5 Control phase test readings.
4	20 Training readings under DAF or periodic visual feedback.*
5	5 Test readings.
6	1 Week interval before 2nd control/training/testing cycle.

*Participants 1,2, and 4 had periodic visual feedback training first. Participants 5 and 6 had DAF training first.

Speech Sample Processing

The analog recorded speech samples from all participant control and test readings were digitized at 22,050 Hz and processed by a noise reduction filter using the Cool Edit V. 96 waveform analysis program (Johnston, 1996). Each participant had a total of 26 speech samples extracted from the 197 syllable test paragraph for analysis. Each sample was 50 contiguous fluent syllables, or if 50 were not available, the closest number approximating this amount, plus or minus three syllables, and up to two identified stuttering moments. An attempt was made to extract the first 50 syllables from each reading to provide consistency across samples, but if this was not possible, the next 50 were taken and so on until a sample was extracted that met the sample criteria. Speech samples for each participant included: The first five control readings, five test readings after periodic visual feedback training, the second five control readings, five test readings after DAF training, and the final five readings under DAF training. In addition, the original reading of the test paragraph during stuttering severity evaluation was analyzed.

Acoustic Parameters of Speech Samples

The beginning and ending points of the speech samples were calculated using the Cool Edit V. 96 waveform analysis program (Johnston, 1996). Two methods were employed. If the beginning or ending phoneme in the sample was a voiced consonant or vowel, the speech sample was analyzed as a waveform. The cut off point was the trough in the waveform immediately preceding or following the beginning or ending of complex periodic vibration. This point was located by recognizing the repeating signature of a complex periodic waveform created by vibration of the vocal folds (Tyler & Saxman, 1991) (see Figure 1).

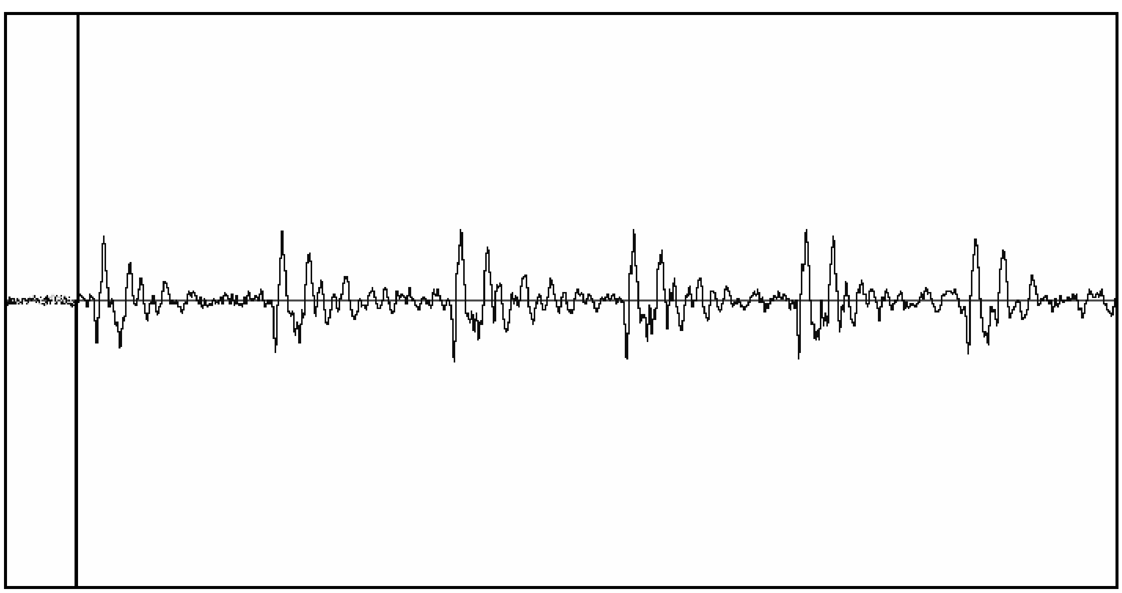


Figure 1. Onset of periodic vocal fold vibration for /n/ in the word “none.”

If the beginning or ending phoneme in a sample was voiceless, a broad band spectrogram was used to determine the point of initiation or termination of plosion, in the case of a stop consonant, or frication, in the case of a fricative (see Figure 2). Once the beginning or ending point of a phoneme had been located, a cursor in the analysis program was placed at the location, and all sample information prior to or after the point of interest was deleted. The analysis program then automatically calculated the duration of the speech sample to the nearest millisecond. If either waveform or spectrogram did not show a clear point of initiation or termination, both waveform and spectrogram were analyzed to help determine onset or offset. This was accomplished by toggling back and forth from waveform to spectrogram with the cursor in the suspected place of onset or offset.

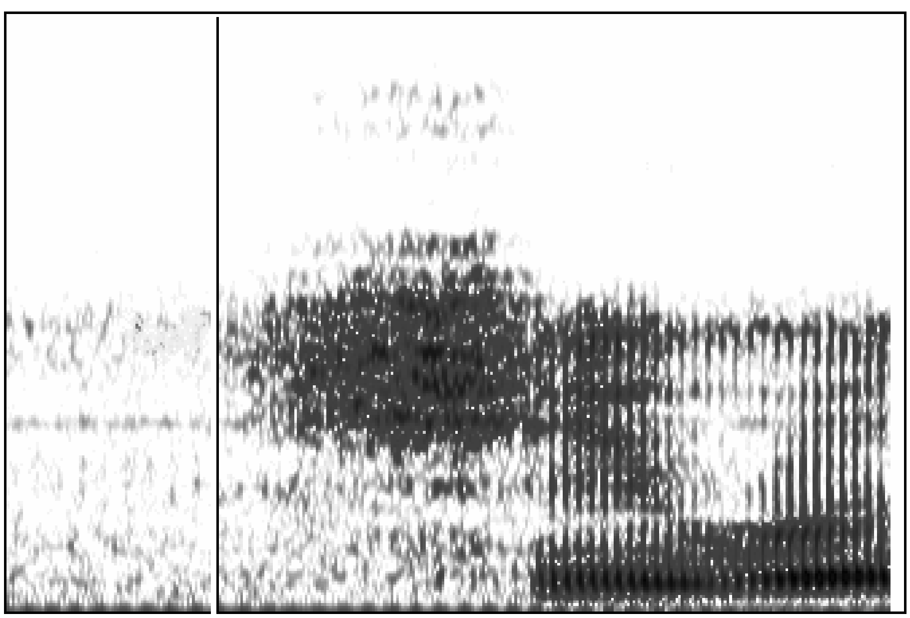


Figure 2. Onset of frication for / / in the word “she.”

Speech Rate Calculation

Participants' speech rates were measured with a procedure similar to the one described by Adams (1976) and refined and implemented by Kalinowski et al. (1996). Speech rate was determined by identifying 50 contiguous fluent syllables, or if 50 were not available, the closest number approximating this amount, plus or minus three syllables, and up to two identified stuttering moments. If all stuttered moments were included, speech rate would be artificially lowered (Adams, 1976). Speech rate was derived by dividing the number of syllables by the duration of the speech sample in milliseconds. Syllables were chosen as the unit of measure instead of words, because it is recognized that the syllable is the motor unit that makes up words, and its length is less variable. These characteristics may allow speech rates that are calculated in syllables to be more accurate than those calculated in words (Perkins, 1973).

Unlike Kalinowski et al. (1996), pause length within speech samples was not manipulated. Instead of identifying all pauses and reducing them in length to 100 ms for each instance, it was felt that all pauses should be included and would provide a more natural and accurate measure of speech rate. Although Butterworth (1980) explained that reading prepared text as opposed to spontaneous speech produced more consistent pausing, pause times did vary somewhat, from 1.0 to 1.24 seconds, within speech samples. Research conducted by Andrews et al. (1982) showed that in the slowed speech condition of their fluency enhancing experiment, the three participants either increased pause time or decreased articulation rate to slow their speech. The slowed movement of the speech articulators, such as the tongue and jaw, was created by the prolonging of syllables. Results indicated participants employed one or the other technique to slow rate, but not both. If pause times were reduced to the same amount in this researcher's study, it was felt that true speech rate would not be represented if some participants chose to increase pause time and others reduced articulation rate while attempting to slow their speech.

Data Analysis

Once all participant speech samples were processed, a visual analysis of the resulting data was necessary, due to the small number of participants and the lack of a separate control group. Each participant's five readings after the initial single control pacing at 155 syllables per minute (spm) was averaged and the standard deviation calculated to determine the central tendency and variability of the initial speech rate without training. Essentially, the mean showed the average rate of the five readings, and the standard deviation showed how consistent the speech rate was. Next, a training phase of 20 readings of the test paragraph under delayed auditory feedback (DAF) or periodic visual feedback was immediately followed by five test readings which were also averaged and the standard deviations determined. Each participant then underwent a second single paragraph control pacing with no additional training one week later. Again, five more readings of the test paragraph were analyzed for central tendency and variability. The second set of control readings allowed the researcher to determine if any training effect had occurred between the first and second experimental conditions. A training effect was probable if a participant was able to bring his or her speech rate closer to the goal rate of 155 spm and improve on standard deviation, with no further training. The second set of control readings were immediately followed by the second training condition. This consisted of 20 more readings of the test paragraph under DAF or periodic visual feedback, followed immediately by five test readings under no feedback contingency. All test readings for each participant were compared with the participant's goal rates for both training conditions. Effective speech rate control was identified by looking at a participant's ability to bring his or her mean speech rate for the final five test readings after training near the goal rates for the training conditions. Also, along with the ability to reduce speech rate as measured by the means of control and test readings, standard deviations for control and test conditions were analyzed to determine if rate control consistency improved. The goal rate for periodic visual feedback was 155 spm. The goal rate for the DAF condition was more individualized, as described below.

In order to better quantify and analyze the mean speech rates that were produced after DAF training, the final five training readings under DAF were recorded and analyzed for central tendency and variability. This occurred, because although 107 ms of DAF created relatively similar slowed speech rates as compared to the 155 spm target rate under periodic visual feedback, the rates produced by the two procedures were not identical. In addition, the literature that describes DAF delay intervals and their correspondence to speech rates includes some variation. Some references report correspondence of DAF delay to speech rate in ranges, such as 100-50 ms produces 100-150 words per minute, while others are more specific. The data, as reported, were not consistent enough to provide an exact speech rate correspondence for 107 ms DAF (Perkins, 1973; Shames and Florance, 1980). In order to develop goal speech rates for the DAF testing phase, individual means had to be determined at the end stage of DAF training. The final five readings of 20 for each participant during DAF training were used as the reference. It was felt that at this point the participants should have settled into a consistent speech rate that they would maintain while prolonging their speech under DAF. It appeared that there was a period of adjustment under DAF, while prolonging speech, that this research attempted to control. This was done by allowing each participant the opportunity to practice under 107ms of DAF for approximately five minutes.

One other method was used to analyze speech rates in order to determine if participants were able to slow their speech consistently. It was a modification of the methodology used in the periodic visual training experiment conducted by Martin and Kuhl (1974). The researchers designated $\pm$ 10% of the goal rate as their gold standard for successful speech rate control. In a situation where the goal rate was consistent among participants, this was an acceptable procedure. If the goal rate was variable, as in the DAF condition of this study, the designation of a fixed percentage would have allowed participants with a higher speech rate a higher range in obtaining the target speech rate. To alleviate this problem, all of the final five readings under DAF for all participants were summed and the mean value was multiplied by ± 20% to determine the range of syllables that would be used to assess speech rate control. A criteria of 20% instead of 10% accuracy was used as a concession to the fact that the participants in Martin and Kuhl's study had up to 300 minutes to practice speech rate, whereas the participants in this study had only approximately 30 minutes for each training condition. The final syllable range for the DAF condition was ± 34.4 syllables. Since the periodic visual feedback and control conditions required a speech rate of 155 spm for all participants, the goal range in syllables was ± 20% of 155, or ± 31 syllables. Control and test phase speech rate data for all participants are summarized in Table 4.

Another area of concern was the speech rate of all five participants during stuttering severity screening. It gave the researcher a base rate of speech in which to compare later test speech rates. If the initial base rate of speech was slow, and comparable to the slowed test speech rates, results could be considered confounded by the participant's habitual speech rate.

Interjudge Agreement

Interjudge agreement has been defined as the extent to which observers agree in their scoring behavior (Kazdin, 1982). Researchers attempt to show that their data, based on observation of events, are consistent and replicable. A major consideration, according to Cordes (1994), is to insure that the data that are being assessed be of importance to the main purpose of the experiment, and not related only in a peripheral sense. In addition, it has been shown that the training of observers to insure that they are looking at the same things and that the items of observation are well defined, has increased levels of agreement among observers (Cordes & Ingham, 1994).

The main area of interest in this study was speech rate and its control through different training procedures. The area of observational data that was of significance was speech rate measurement. Interjudge agreement of speech rate measures was calculated by randomly selecting 10% of the control and experimental speech samples for each participant and having an independent judge re-calculate speech rates after being trained with the procedure used for this research. A Pearson product moment correlation (r) was then calculated to determine the interrater reliability.

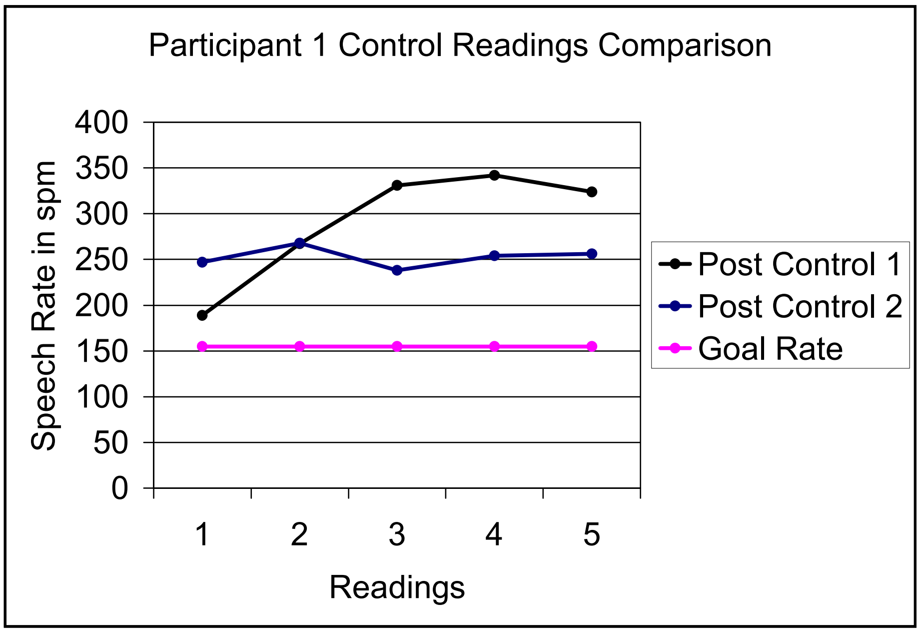
Chapter III.

Results

Participant 1

Control Conditions

Participant 1 was male. Results of the SSI-3 (Riley, 1994) indicated that he was in the mild range of stuttering severity. Participant 1 was randomly assigned to undergo periodic visual feedback as the first training condition, and then DAF as the second training condition a week later. Immediately prior to the initial training phase, participant 1 was paced once with continuous visual feedback at 155 spm while reading the test paragraph. The test paragraph was displayed on the Dell laptop computer and each of the 197 syllables were individually highlighted at a rate of 155 spm. Participant 1 was required to read along with the highlighting to produce a speech rate of 155 spm. The first set of five control readings after being paced by the computer averaged 290.6 spm, with a standard deviation of 63.7. A week later, the second set of five control readings prior to DAF training averaged 252.6 spm, with a standard deviation of



11.1. Considering the speech rate of 155 spm that participant 1 attempted to maintain during the control readings, it appeared that without training, he was unable to consistently reduce his speech rate. When the additional speech rate accuracy criteria of $\pm$ 31 spm of the target rate was applied to all post control test readings, none of them fell into the designated target range. This was further evidence of a lack of speech rate control. The relationship between the speech rate variability during the control phases as compared to the goal speech rate for participant 1 is graphically represented in Figure 3.

Figure 3. Speech rate comparison of control readings and goal rate for participant 1.

The reduction of approximately 40 spm from the mean speech rate of control phase one to control phase two one week later, and the improvement of the standard deviation from 63.7 to 11.1, gave the impression that a training effect had occurred. Any training effect was negligible, as participant 1's most accurate reading of the second control group was only within 83 spm of the target rate. Speech rate consistency may have improved, but the main issue of reduction of speech rate showed very little improvement.

Experimental Conditions

Periodic visual feedback condition. Participant 1 was randomly assigned to periodic visual feedback as the first training condition. He was required to read the test paragraph 20 times, and attempted to produce a speech rate of 155 spm for each reading. After each reading, the Studder computer program (Boyce, 1998) displayed the speech rate, including stuttering moments, for participant 1 to use to adjust his speech rate for the next training reading. After 20 training readings of the test paragraph, the five subsequent test readings under no feedback contingency resulted in a mean speech rate of 179.2 spm with a standard deviation of 12.9. Considering the target speech rate of 155 spm during periodic visual feedback training, the results appeared to show a marked improvement in the ability to reduce speech rate as compared to the prior control readings. When the speech rate accuracy criteria of ± 31 spm of the target rate was applied to all periodic visual feedback test readings, 4 of the

5 readings fell within the target range . The improvement in rate control after periodic visual feedback training is graphically represented in Figure 4.

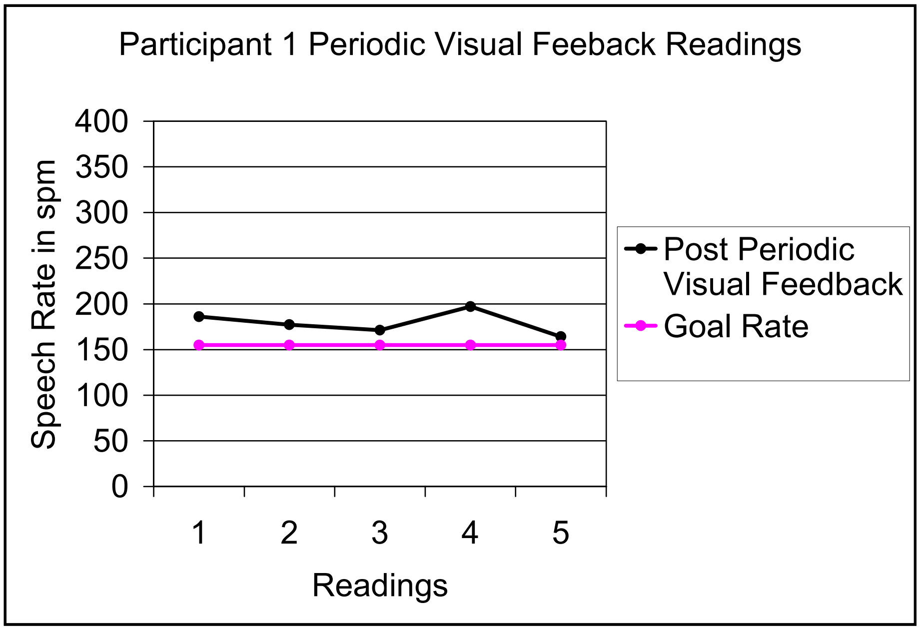
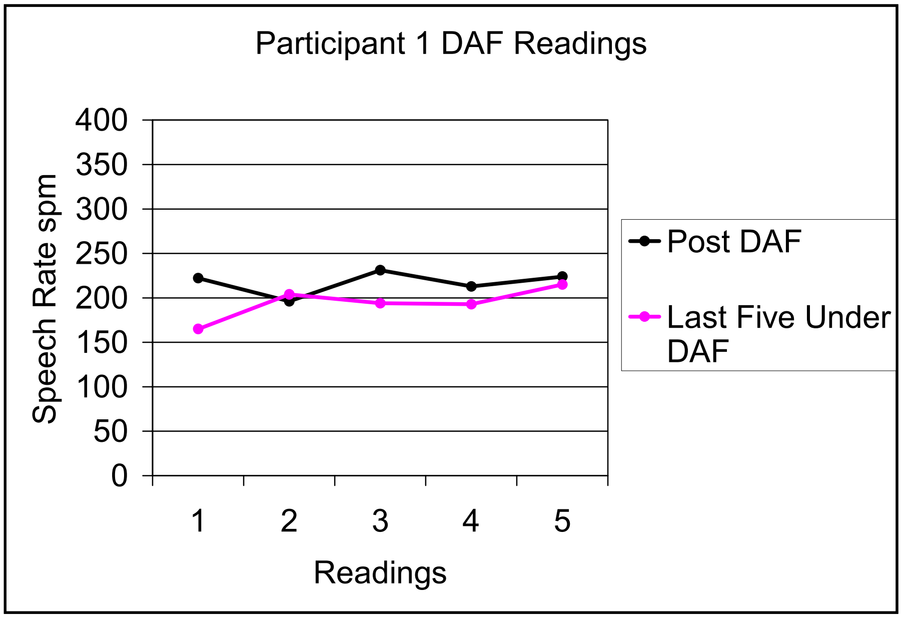


Figure 4. Speech rate comparison of periodic visual feedback readings and goal rate for participant 1.

DAF condition. Participant 1 underwent delayed auditory feedback (DAF) training one week after completion of periodic visual feedback training and testing. After 20 training readings of the test paragraph, the five subsequent test readings under no feedback contingency resulted in a mean speech rate of 217.2 spm with a standard deviation of 13.5. As explained in the data analysis section on page 30, the mean speech rate of the final five training readings under DAF were used as the goal speech rate for DAF test readings. Participant 1 averaged 194.2 spm with a standard deviation of 18.6 for the final five readings under DAF. Participant 1 appeared to be able to maintain a consistent lowered speech rate after DAF training. This was supported when the speech rate accuracy criteria of ± 34.4 spm of the target rate was applied to all DAF test readings. All readings fell within the accuracy criteria. Participant



1's successful rate control is graphically represented in Figure 5.

Figure 5. Speech rate comparison of DAF readings and goal rate for participant 1.

Screening Speech Rate Analysis

As part of the initial participation selection process, each participant was screened for stuttering severity. A portion of the screening involved reading. The test paragraph was utilized for the reading portion of the screening in order to compare habitual speech rate with later experimental speech rates. This was done to determine if the habitual speech rate was unusually low and coincidentally in the range of the goal speech rates after DAF and periodic visual feedback training. If this was the case, it could be determined that any speech rate control displayed after either training contingency actually reflected habitual speech rate. Speech rate for participant 1 during stuttering screening was 261 spm, and was well above later test reading speech rates. This confirmed that Participant 1's habitual speech rate was of no consequence in his apparent rate control ability.

Participant 2

Control Conditions

Participant 2 was male. Results of the SSI-3 (Riley, 1994) indicated that he was in the mild range of stuttering severity. Participant 2 was randomly assigned to undergo periodic visual feedback as the first training condition, and then DAF as the second training condition a week later. Immediately prior to the initial training phase, participant 2 was paced with continuous visual feedback at 155 spm while reading the test paragraph. The first set of five control readings after being paced by the computer averaged 152.4 spm, with a standard deviation of 13.3. A week later, the second set of control readings prior to DAF training averaged 184.6 spm, with a standard deviation of 16.3. Considering the speech rate of 155 spm that participant 2 attempted to maintain during the control readings, it appeared that he was able to reduce his speech rate fairly well without training. This was supported by the speech rate accuracy criteria, with 8 of 10 control readings within the ± 31 spm range. One possible explanation for participant 2's ability to reduce speech rate consistently without training is an unusual ability to manipulate speech rate. The relationship between the speech rates during the control phases as compared to the goal speech rate for participant 2 is graphically represented in Figure 6.

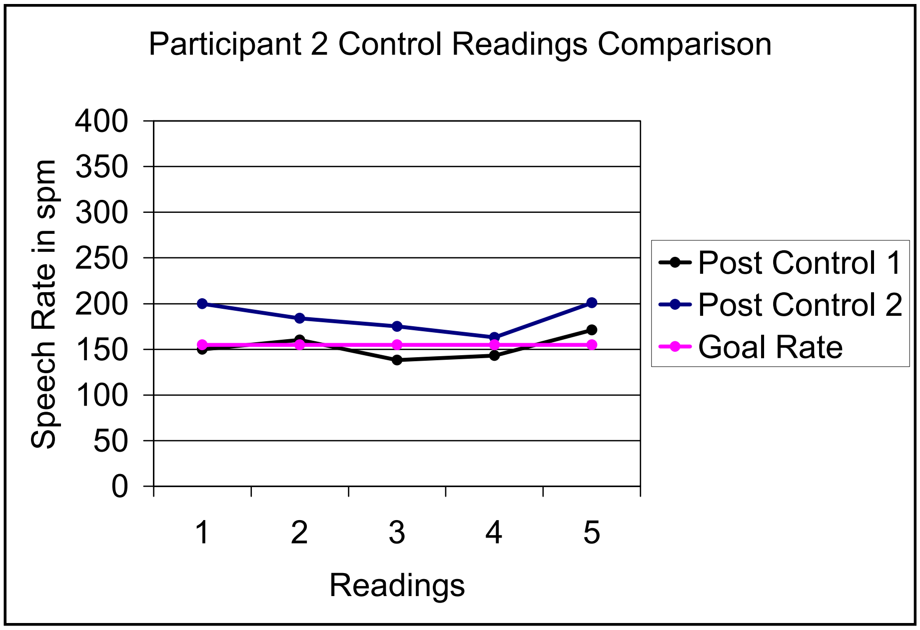


Figure 6. Speech rate comparison of control readings and goal rate for participant 2.

In addition, the rise of over 30 spm with a higher standard deviation from the first control phase to the second control phase suggested there was no training effect created by the first training condition of periodic visual feedback. If a training effect had occurred, the mean speech rate of the second control phase should have remained closer to the goal rate of 155 spm and the second control phase standard deviation should have improved as well.

Experimental Conditions

Periodic visual feedback condition. Participant 2 was randomly assigned to periodic visual feedback as the first training condition. After 20 training readings of the test paragraph, the five subsequent test readings under no feedback contingency resulted in a mean speech rate of 146.6 spm with a standard deviation of 11.5. This appeared to show a continued ability to reduce speech rate consistently. The speech rate accuracy criteria of ± 31 spm of target rate confirmed this result, with all test readings well within the target range. This rate control ability is graphically represented in Figure 7.

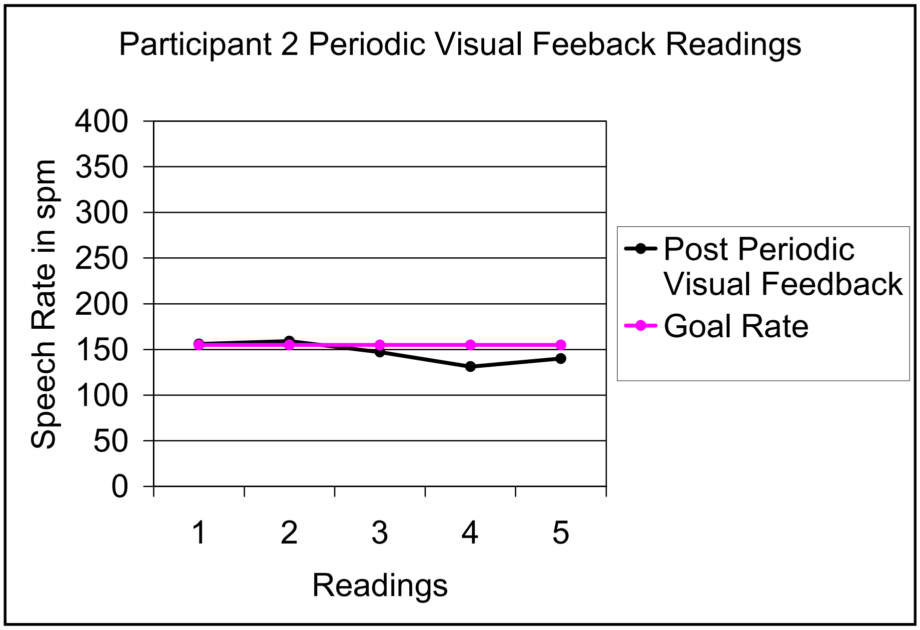


Figure 7. Speech rate comparison of periodic visual feedback readings and goal rate for participant 2.

DAF condition. Participant 2 underwent DAF training one week after completion of periodic visual feedback training and testing. After 20 training readings of the test paragraph, the five subsequent test readings under no feedback contingency resulted in a mean speech rate of 139.6 spm with a standard deviation of 9.6. Participant 2 averaged 153.8 spm with a standard deviation of 9.3 for the final five training readings under DAF. The mean of the final five training readings were used as the DAF goal speech rate for participant 2. It appeared that participant 2 continued to display the ability to maintain a consistent lowered speech rate after DAF training. In fact, the standard deviations for the DAF training and testing readings were the lowest for any phase of training among all participants. The speech rate accuracy criteria also suggested excellent rate control after DAF training. All test readings after DAF were within the ± 34.4 spm range. Participant 2's rate control ability after DAF training is graphically represented in Figure 8.

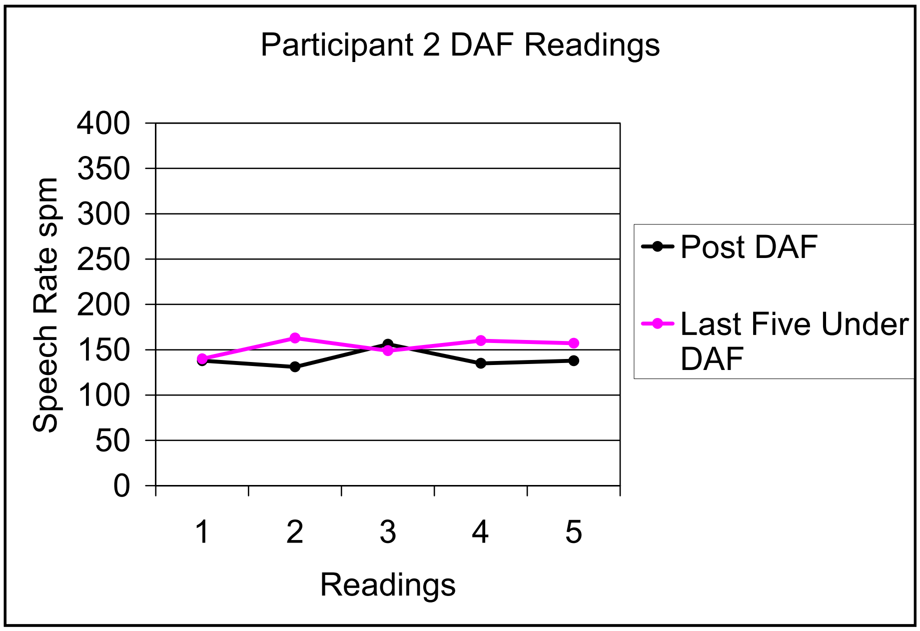


Figure 8. Speech rate comparison of DAF readings and goal rate for participant 2.

Screening Speech Rate Analysis

During initial stuttering screening, the speech rate for participant 2 was 192 spm, which was considerably higher than later test reading speech rates. This appeared to confirm that participant 2's habitual speech rate did not give him an advantage in speech rate control in later control and test readings.

Participant 3

Participant 3 was male. Results of the SSI-3 (Riley, 1994) indicated that he was in the severe range of stuttering severity. It was also noted that he was much more disfluent while reading than during conversational speech. His percentage of syllables stuttered during conversational speech was 18%, while during reading it was 35%. Participant 3 was randomly assigned to undergo periodic visual feedback as the first training condition, and then DAF as the second training condition a week later. Participant 3's stuttering while reading was resistant to the improved fluency of the adaptation effect, and he continued to stutter severely through the initial control and into the periodic visual feedback training readings. In fact, he stuttered so severely that he was unable to get his reported speech rate during periodic visual feedback training up beyond 50 or 60 spm. This was because the Studder computer program (Boyce, 1998) reported speech rate as a measure including all stuttering moments. This situation caused participant 3 to become visibly frustrated with the testing procedure, and his participation in the experiment was ended by mutual consent. No specific speech rate data obtained from participant 3 were included in this study.

Prior to training and testing, participant 3 had expressed interest in DAF, and therefore he was allowed to experience its effects while reading one week later. Not surprisingly, participant 3 displayed a marked improvement in fluency while reading under DAF, and was better able to read the test paragraph, although no measures of stuttering frequency or speech rate were attempted. The issue of stuttering severity and its effect on this study are further explored in the discussion section on page. 66.

Participant 4

Control Conditions

Participant 4 was male. Results of the SSI-3 (Riley, 1994) indicated that he was in the moderate range of stuttering severity. Participant 4 was randomly assigned to undergo periodic visual feedback as the first training condition, and then DAF as the second training condition a week later. Immediately prior to the initial training phase, participant 4 was paced with continuous visual feedback at 155 spm while reading the test paragraph. The first set of five control readings after being paced by the computer averaged 249.2 spm, with a standard deviation of 17.3. A week later, the second set of control readings prior to DAF training averaged 259.0 spm, with a standard deviation of 16.8. Considering the speech rate of 155 spm that participant 4 attempted to maintain during the control readings, it appeared that he was unable to consistently reduce his speech rate without training. The speech rate accuracy criteria of ± 31 spm confirmed poor rate control, with all control readings close to 100 spm beyond the accepted range. The relationship between the speech rates during the control phases as compared to the goal speech rate for participant 4 is graphically represented in Figure 9.

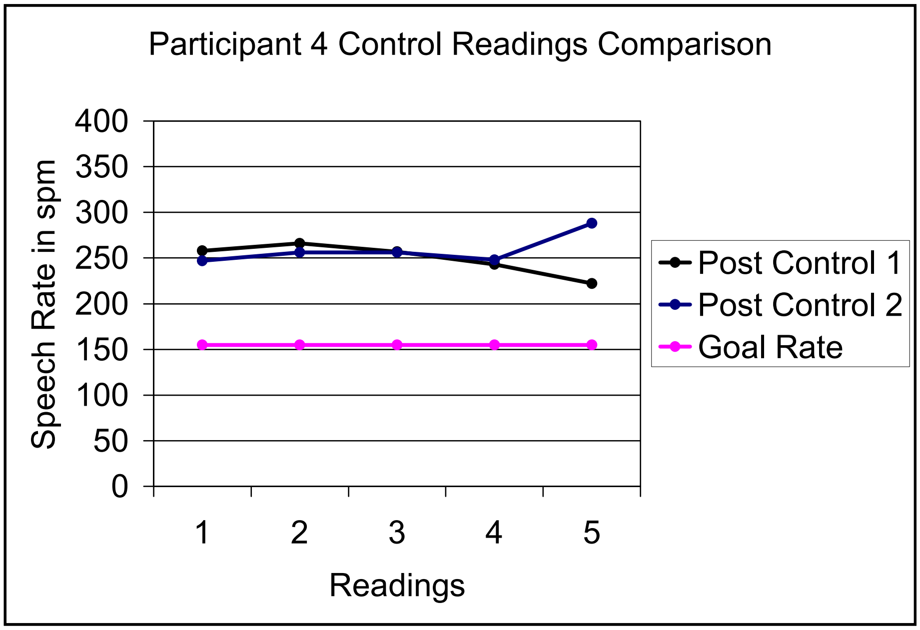


Figure 9. Speech rate comparison of control readings and goal rate for participant 4.

In addition, the fact that the mean speech rates for the first and second control phases were within 10 spm of each other, and nearly identical in standard deviation, suggested there was no training effect created by the first training condition of periodic visual feedback.

Experimental Conditions

Periodic visual feedback condition. Participant 4 was randomly assigned to periodic visual feedback as the first training condition. After 20 training readings of the test paragraph, the five subsequent test readings under no feedback contingency resulted in a mean speech rate of 241.2 spm with a standard deviation of 24.9. Participant 4 appeared unable to effectively maintain a reduced speech rate after periodic visual feedback training. The mean speech rate was very near his control phase speech rates, and well above the target rate of 155 spm. The speech rate accuracy criteria of ± 31 spm also showed all periodic visual feedback test readings well outside the target range. The relationship between the mean speech rate after periodic visual feedback training as compared to the goal speech rate for participant 4 is graphically represented in Figure 10.

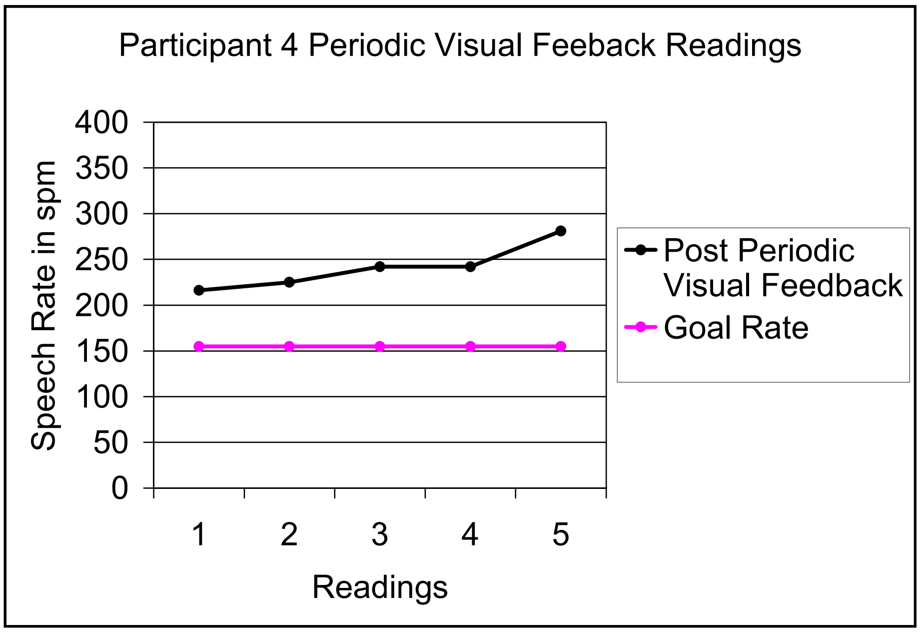


Figure 10. Speech rate comparison of periodic visual feedback readings and goal rate for participant 4.

DAF Condition. Participant 4 underwent DAF training one week after completion of periodic visual feedback training and testing. After 20 training readings of the test paragraph, the five subsequent test readings under no feedback contingency resulted in a mean speech rate of 231.4 spm with a standard deviation of 22.4. Participant 4 averaged 175.2 spm with a standard deviation of 13.3 for the final five training readings under DAF. The mean of the final five training readings were used as the DAF goal speech rate for participant 4. It appeared he was unable to effectively maintain a reduced speech rate after DAF training. The mean speech rate was well above the target rate of 175.2 spm, with a near doubling in standard deviation. This result was confirmed by the speech rate accuracy criteria of ± 34.4 spm. Only 1 of the 5 DAF test readings fell within the accuracy range. The relationship between the mean speech rate after DAF training as compared to the goal speech rate for participant 4 is graphically represented in Figure 11.

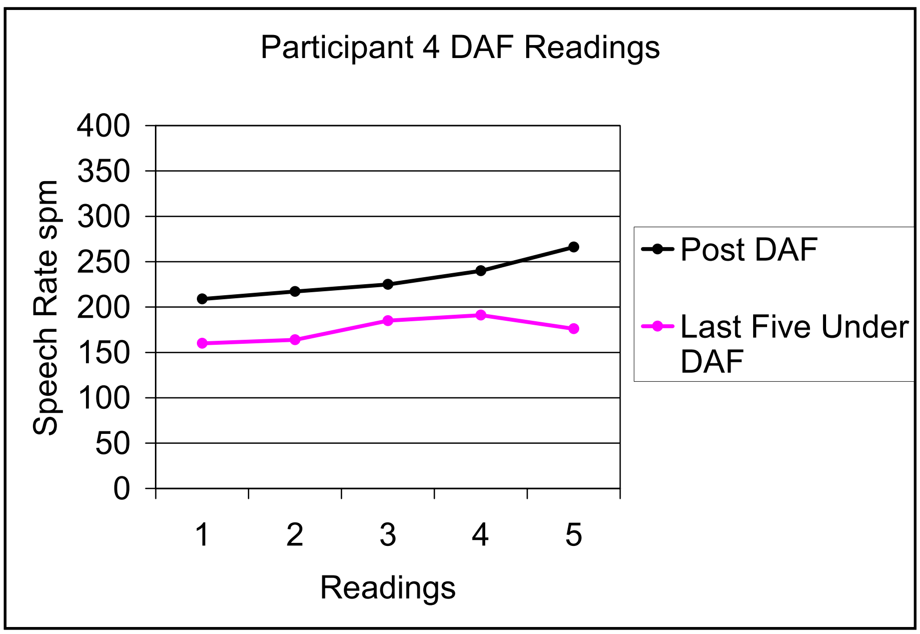


Figure 11. Speech rate comparison of DAF readings and goal rate for participant 4.

Screening Speech Rate Analysis

During initial stuttering screening, the speech rate for participant 4 was 235 spm, which was in the range of later control and test reading speech rates. This appeared to confirm that participant 4 was unable to maintain a consistent reduced speech rate in any training condition.

Participant 5

Control Conditions

Participant 5 was male. Results of the SSI-3 (Riley, 1994) indicated that he was in the moderate range of stuttering severity. Participant 5 was randomly assigned to undergo DAF as the first training condition, and then periodic visual feedback as the second training condition a week later. Immediately prior to the initial training phase, participant 5 was paced with continuous visual feedback at 155 spm while reading the test paragraph. The first set of five control readings after being paced by the computer averaged 221.6 spm, with a standard deviation of 23.9. A week later, the second set of control readings prior to periodic visual feedback training averaged 217.0 spm, with a standard deviation of 15.6. Considering the speech rate of 155 spm that participant 5 attempted to maintain during the control readings, it appeared that he was unable to consistently reduce his speech rate without training. This was confirmed by the application of the ± 31 spm speech rate accuracy criteria. All control readings were outside the acceptable accuracy range. The relationship between the speech rates during the control phases as compared to the goal speech rate for participant 5 is graphically represented in Figure 12.

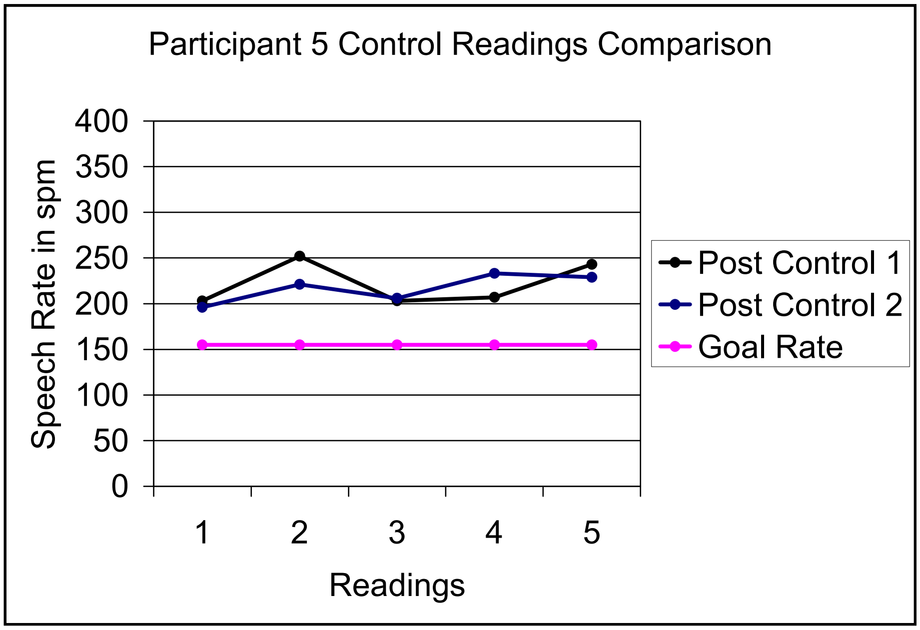


Figure 12. Speech rate comparison of control readings and goal rate for participant 5.

In addition, the fact that the mean speech rates for the first and second control phases were within five spm of each other suggested there was no training effect created by the first DAF training condition. Although the standard deviation of speech rate improved from 23.9 to 15.6, suggesting an improvement in the ability to maintain a specified speech rate, the mean speech rates were still well above the target rate of 155 spm.

Experimental Conditions

DAF condition. Participant 5 was randomly assigned to DAF as the first training condition. After 20 training readings of the test paragraph, the five subsequent test readings under no feedback contingency resulted in a mean speech rate of 198.0 spm with a standard deviation of 15.0. Participant 5 averaged 155.2 spm with a standard deviation of 18.1 for the final five training readings under DAF. The mean of the final five training readings were used as the DAF goal speech rate for participant 5. It appeared he was unable to effectively maintain a reduced speech rate after DAF training. The mean speech rate of the DAF test readings was over 40 spm above the target rate of 155.2 spm, with a slight improvement in standard deviation. In addition, the mean speech rate of the DAF test readings was within approximately 20 spm of the control readings, suggesting not much changed in speech rate from the control to the experimental conditions. When the speech rate accuracy criteria of ± 34.4 spm of the goal rate was applied, 3 of the 5 DAF test readings were outside the target range. The relationship between the mean speech rate after DAF training as compared to the goal speech rate for participant 5 is graphically represented in Figure 13.

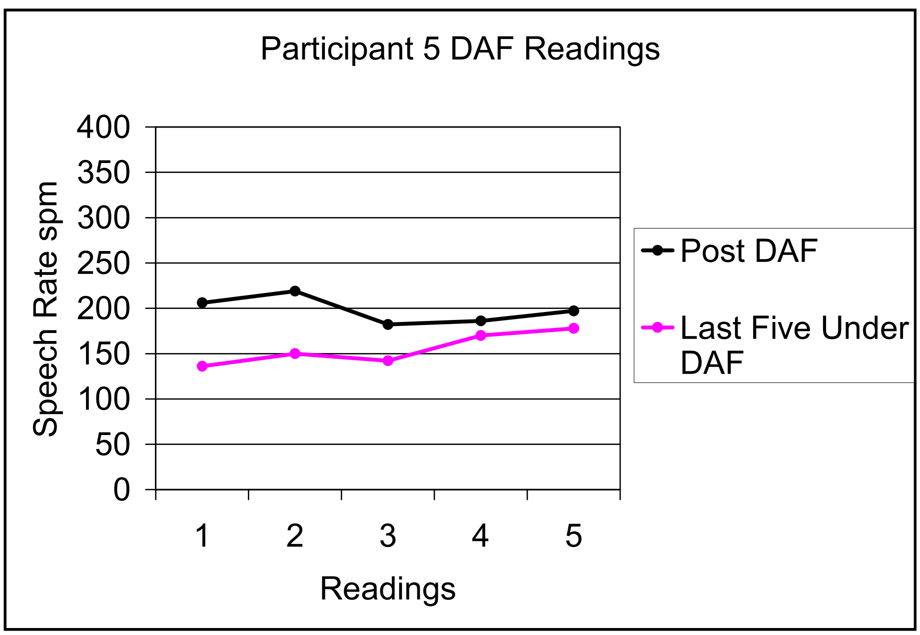


Figure 13. Speech rate comparison of DAF readings and goal rate for participant 5.

Periodic visual feedback condition. Participant 5 underwent periodic visual feedback training one week after completion of DAF training and testing. After 20 training readings of the test paragraph, the five subsequent test readings under no feedback contingency resulted in a mean speech rate of 207.8 spm with a standard deviation of 25.0. Participant 5 appeared unable to effectively maintain a reduced speech rate after periodic visual feedback training. The mean speech rate was over 50 spm above the target rate of 155 spm. The mean of the post periodic visual feedback training speech rates, like that of DAF, was very near the control phase speech rates, suggesting little change in speech rate from control to experimental conditions. When the speech rate accuracy criteria of $\pm$ 31 spm of the goal rate was applied, 4 of the 5 periodic visual feedback test readings were outside the target range. The relationship between the mean speech rate after periodic visual feedback training as compared to the goal speech rate for participant 5 is graphically represented in Figure 14.

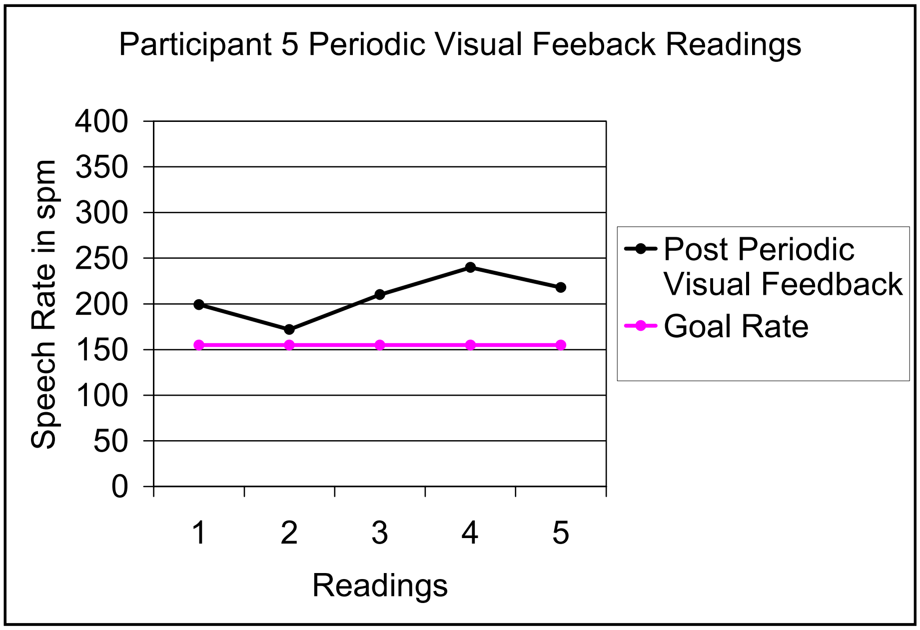


Figure 14. Speech rate comparison of periodic visual feedback readings and goal rate for participant 5.

Screening Speech Rate Analysis

During initial stuttering screening, the speech rate for participant 5 was 229 spm, which was in the range of later control and test reading speech rates. This appeared to confirm that participant 5 was unable to maintain a consistent reduced speech rate in any training condition.

Participant 6

Control Conditions

Participant 6 was female. Results of the SSI-3 (Riley, 1994) indicated that she was in the moderate range of stuttering severity. Participant 6 was randomly assigned to undergo DAF as the first training condition, and then periodic visual feedback as the second training condition a week later. Immediately prior to the initial training phase, participant 6 was paced with continuous visual feedback at 155 spm while reading the test paragraph. The first set of five control readings after being paced by the computer averaged 274.4 spm, with a standard deviation of 26.0. A week later, the second set of control readings prior to periodic visual feedback training averaged 286.0 spm, with a standard deviation of 31.0. Considering the speech rate of 155 spm that participant 6 attempted to maintain during the control readings, it appeared that she was unable to consistently reduce her speech rate without training. This was supported by the speech rate accuracy criteria of ± 31 spm of the goal rate. All ten of the post control test readings were approximately 100 spm above the 155 spm goal rate. The relationship between the speech rates during the control phases as compared to the goal speech rate for participant 6 is graphically represented in Figure 15.

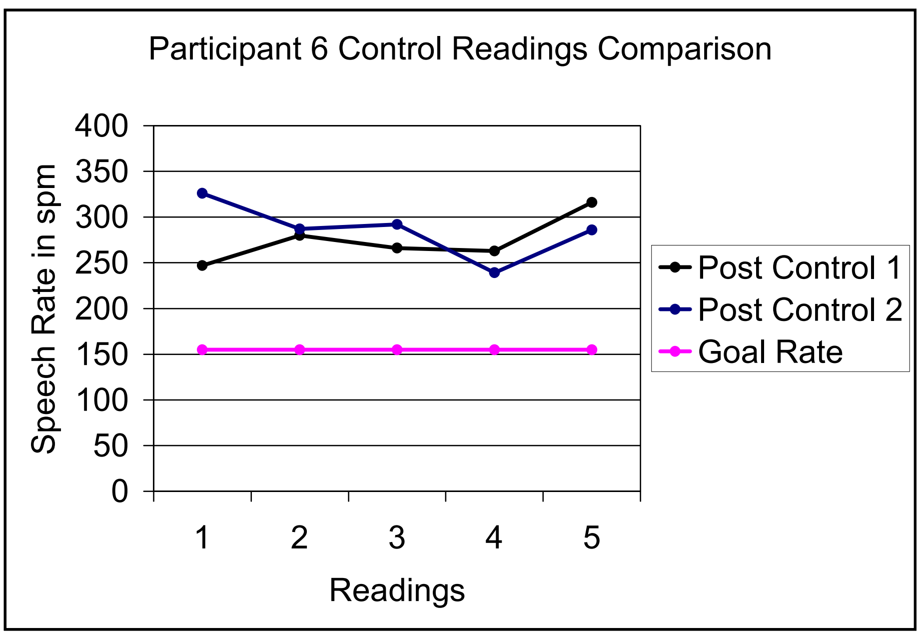


Figure 15. Speech rate comparison of control readings and goal rate for participant 6.

In addition, the mean speech rates for the first and second control phases were within 12 spm of each other. They were also close in standard deviation, suggesting there was no training effect created by the first training condition of periodic visual feedback.

Experimental Conditions

DAF condition. Participant 6 was randomly assigned to DAF as the first training condition. After 20 training readings of the test paragraph, the five subsequent test readings under no feedback contingency resulted in a mean speech rate of 277.6 spm with a standard deviation of 13.6. Participant 6 averaged 181.2 spm with a standard deviation of 9.7 for the final five training readings under DAF. The mean of the final five training readings were used as the DAF goal speech rate for participant 6. It appeared that she was unable to effectively maintain a reduced speech rate after DAF training. The mean speech rate for the test readings was over 90 spm above the target rate of 181.2 spm, with a larger standard deviation than the target readings. In addition, the mean speech rate of the DAF test readings was within 10 spm of the control readings, suggesting not much changed in speech rate from the control to the experimental conditions. The speech rate accuracy criteria of ± 34.4 spm was not met by any of the DAF test readings, lending further support for a lack of rate control. The relationship between the mean speech rate after DAF training as compared to the goal speech rate for participant 6 is graphically represented in Figure 16.

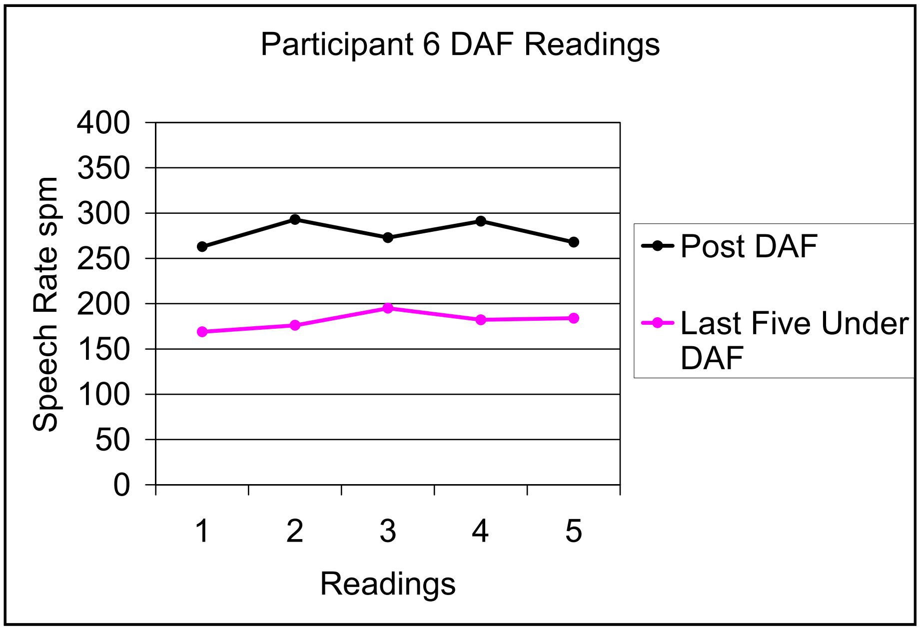


Figure 16. Speech rate comparison of DAF readings and goal rate for participant 6.

Periodic visual feedback condition. Participant 6 underwent periodic visual feedback training one week after completion of DAF training and testing. After 20 training readings of the test paragraph, the five subsequent test readings under no feedback contingency resulted in a mean speech rate of 215.4 spm with a standard deviation of 26.5. Participant 6 appeared unable to effectively maintain a reduced speech rate after periodic visual feedback training. The mean speech rate was over 60 spm above the target rate of 155 spm. Application of the speech rate accuracy criteria of ± 31 spm of the target rate also suggested poor rate control. Only 1 of 5 test readings fell within the goal range. The relationship between the mean speech rate after periodic visual feedback training as compared to the goal speech rate for participant 6 is graphically represented in Figure 17.

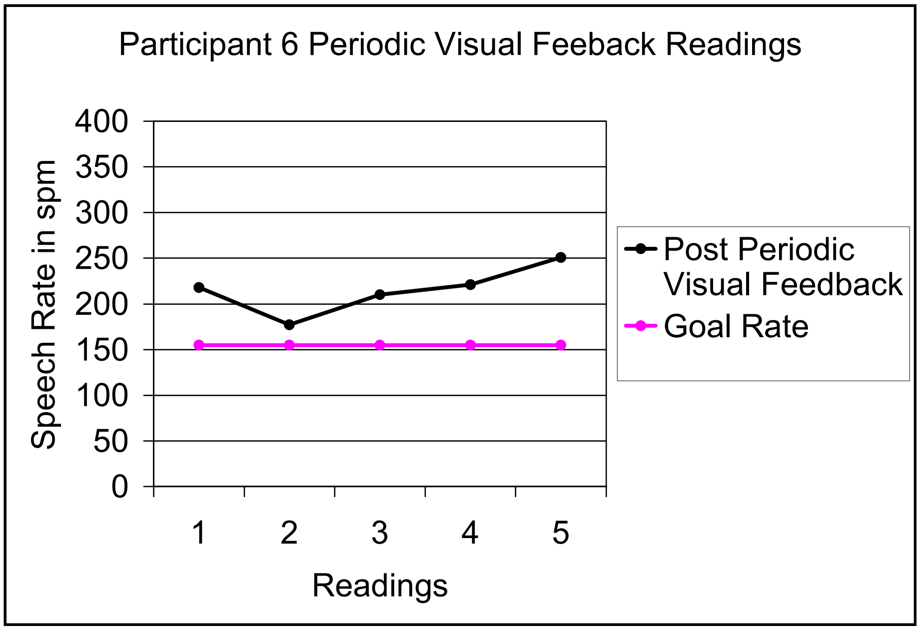


Figure 17. Speech rate comparison of periodic visual feedback readings and goal rate for participant 6.

Screening Speech Rate Analysis

During initial stuttering screening, the speech rate for participant 6 was 244 spm, which was in the range of most of the later control and test reading speech rates. Participant 6 appeared unable to consistently reduce speech rate under any condition.

Interjudge Agreement

Interjudge agreement of speech rate measures was calculated by randomly selecting 10% of the control and experimental speech samples for each participant and having an independent judge re-calculate speech rates. The independent judge was trained in the speech rate calculation procedure used for this research. A Pearson product moment correlation (r) was then calculated to determine the interrater reliability. An extremely high correlation of

.99 was calculated, suggesting a high reliability for the speech rate measures in this research. In fact, a comparison of the speech rate measures between the researcher and the independent judge showed that the largest difference was 2.2 syllables per minute, with an average difference of .72 syllables per minute. Table 3 shows the Pearson product moment correlation (r) and speech rates calculated in syllables per minute (spm) by the researcher in column 1 and the independent judge in column 2.

Table 3

Pearson Product Moment Correlation (r) of Randomly Selected Speech Samples

	Column 1	Column 2
Column 1	1	
Column 2	.99	1

Researcher	Independent Judge
Column 1	Column 2
267	266.8
165.7	165.9
186.5	186.3
149.6	150.5
140.8	141
159.4	159.2
257.9	257.1
159.6	158.9
216.4	217.3
251.9	252.3
142.3	142
218.4	219.6
265.9	263.7
194.5	194.9
177.1	179.1

Table 4

Participant Control and Test Phase Speech Rate Data

Condition

Participants	1st Control	2nd Control	Periodic Visual	DAF goal rate	DAF
1	*M*: 290.6 *SD*: 63.7 0/5	*M:* 252.6 *SD*: 11.1 0/5	*M*: 179.0 *SD*: 12.9 4/5	*M*: 194.2 *SD*: 18.6	*M*: 217.2 *SD*: 13.5 5/5
2	*M*: 152.4 *SD*: 13.3 5/5	*M*: 184.6 *SD*: 16.3 3/5	*M*: 146.6 *SD*: 11.5 5/5	*M*: 153.8 *SD*: 9.3	*M*: 139.6 *SD*: 9.6 5/5
4	*M*: 249.2 *SD*: 17.3 0/5	*M*: 259.0 *SD*: 16.8 0/5	*M*: 241.2 *SD*: 24.9 0/5	*M*: 175.2 *SD*: 13.3	*M*: 231.4 *SD*: 22.4 1/5
5	*M*: 221.6 *SD*: 23.9 0/5	*M*: 217.0 *SD*: 15.6 0/5	*M*: 207.8 *SD*: 25.0 1/5	*M*: 155.2 *SD*: 18.1	*M*: 198.0 *SD*: 15.0 2/5
6	*M*: 274.4 *SD*: 26.0 0/5	*M*: 286.0 *SD*: 31.0 0/5	*M*: 215.4 *SD*: 26.5 1/5	*M*: 181.2 *SD*: 9.7	*M*: 277.6 *SD*: 13.6 0/5

Data Includes Mean, Standard Deviation, and Number of Readings that Meet Speech Rate Range Criteria.

Chapter IV.

Discussion

Research Hypothesis and Method Re-Visited

The research hypothesis that was presented in the beginning of this study stated that the use of delayed auditory feedback (DAF) to systematically train reduced rate of speech might produce more accurate rate control than periodic feedback of speech rate training in individuals who stutter. At the time, the main factor, or independent variable, that was felt would affect the ability to maintain consistent speech rate, was the type of rate control training method that was used. Review of the literature concerning speech rate training with people who stutter presented three training methods. They included delayed auditory feedback (DAF), or the digital delay of speech before it reaches the ears, periodic visual feedback, or the periodic visual reinforcement of speech rate, and continuous visual feedback, or the continuous visual reinforcement of speech rate. DAF and periodic visual feedback were chosen as the training methods, because it was felt that continuous visual feedback was poorly suited to persons who stutter, especially in the beginning of fluency treatment programs. The continuous visual feedback method, which can take the form of words in a paragraph being highlighted at a fixed rate as a paragraph is read, can place time pressure on those who stutter, possibly increasing anxiety and stuttering behaviors.

Six participants took part in this study, one female and five males, with one male participant's speech rate data excluded because he was unable to complete all portions of the study. Participants were required to undergo DAF and periodic visual feedback training of speech rate with one week in between training sessions to control for training effect. During the study, a 197 syllable test paragraph was read 36 times for both DAF and periodic visual feedback conditions. This included control, training, and testing phases of the study. Speech rates were calculated for all phases in an attempt to determine participants' untrained as well as trained abilities to maintain a consistent speech rate.

Effectiveness of DAF and Periodic Visual Feedback

A review of the results section in this study indicates that both DAF and periodic visual feedback can be effective speech rate training methods in individuals who stutter. If the results for all five participants are analyzed, it shows that two of the five participants were able to maintain consistent speech rates after training under DAF and periodic visual feedback. The assessment of speech rate control included analysis of means and standard deviations of experimental speech rates, visual analysis of experimental vs. goal speech rates, and conformity to a speech rate control criteria based on a specified speech rate range. Participants 1 and 2 were the only ones able to meet the speech rate control criteria described above, and they did it about equally well after DAF and periodic visual feedback training (see Figures 3-8). There was no obvious difference in either participant's ability to maintain a consistent speech rate after DAF or periodic visual feedback training. Conclusions based on this study concerning whether DAF or periodic visual feedback is the more effective training method across all people who stutter cannot be made. The sample size was not large enough, and only two of the five participants displayed effective speech rate control based on the criteria of this study.

DAF and Periodic Visual Feedback Training Trends

Since participants 1 and 2 were the only participants able to control their speech rates after both DAF and periodic visual feedback training, the obvious question that arises is why weren't the other three participants able to do so also? If the speech rate training trends of all participants for both DAF and periodic visual feedback training are analyzed, a pattern emerges that suggests that perhaps more than one variable affects a person's ability to maintain a consistent speech rate.

Figure 18 represents all of the speech rates for all participants during DAF training. Figure 19 represents all of the speech rates for all participants during periodic visual feedback training. The speech rates were automatically recorded by the Studder computer program (Boyce, 1988) and include stuttering moments. As mentioned before, this measure of speech rate is artificially lowered as compared to speech rate measures that are fluent, but it is accurate enough to reflect an overall training trend for all participants. In fact, with the adaptation effect, or the lowering of stuttering frequency created by multiple readings of the same material, all participants displayed reduced stuttering behaviors during the training and testing phases of this study. When figures 18 and 19 are studied, the most obvious trend observed is that all participants, not just participants 1 and 2, were able to keep their speech rates grouped relatively closely together during DAF and periodic visual feedback training. In fact, all participants were within 49 syllables per minute (spm) of each other at the end of DAF training, and within 52 spm of each other at the end of periodic visual feedback training. It was when participants were required to transfer this rate control to speech without feedback contingency that there was an obvious difference in rate control ability among participants.

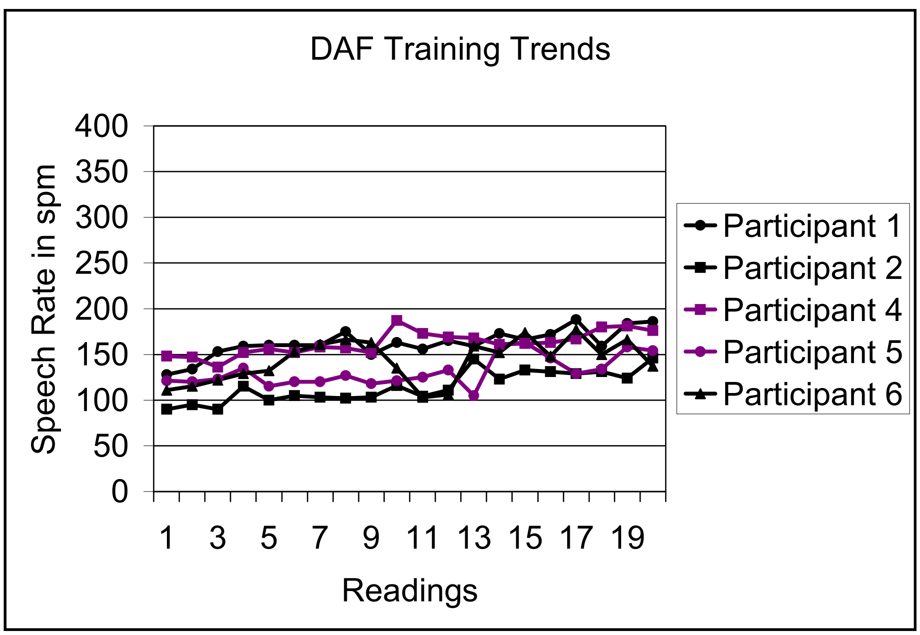


Figure 18. Speech rate comparison of DAF training readings for all participants.

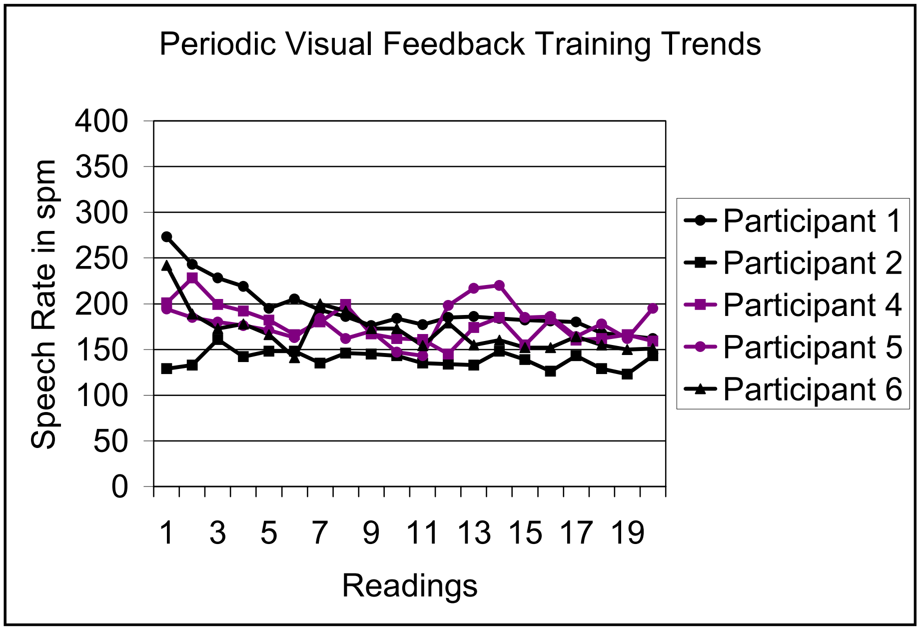


Figure 19. Speech rate comparison of periodic visual feedback training readings for all participants.

This suggests that the training methods themselves may both be effective in providing speech rate consistency during training, but that other factors may be involved which allow some participants to control their speech rates consistently after training is completed.

Variables That May Affect Speech Rate Control Ability

The data in this study suggest that speech rate control ability may involve other factors besides method of rate training which contribute to a person's ability to maintain a consistent speech rate after training. Participants 1 and 2 appeared to display relatively equal ability to control speech rate after both DAF and periodic visual feedback training. However, it must be reiterated that the sample size of just five participants precludes making definitive statements about the effectiveness or superiority of DAF or periodic visual feedback as rate control training methods for all people who stutter. It is possible that if this study was duplicated with a larger number of participants, a trend might appear that indicates individual predisposition for a training method that is either visual or auditory in nature. This could be due to individual learning styles that are geared more toward auditory (DAF) or visual (periodic visual feedback) learning.

The possibility of individual predisposition for a particular learning style raises a second variable that may affect speech rate control ability. The variable is motivation or preference, and it could be closely linked to predisposition. It is possible that people prefer one method of speech rate training over another, and this preference could have an effect on speech rate control ability. Preference for training method was voiced by two of the five participants in this study. It may even be seen that people's preference in rate control training method mirrors the method that is most suited to their learning style. It becomes a circular argument as to which variable may influence the other, preference for training method, or predisposition toward a particular training method.

A third variable that may affect speech rate control is comprehension of research procedures and requirements. An effort was made in this research to interact with each participant in the same way to attempt to control the possibility of researcher influence on either training method. Scripts were read to all participants explaining the experimental procedures for both DAF and periodic visual feedback training and testing. It is possible that there was a difference between participants in understanding what was expected of them, especially in going from the training phases of the study to the testing phases. Perhaps the introduction of a systematic re-iteration of instructions and a method for checking comprehension would help to control this variable.

A fourth variable that may affect speech rate control is level of stuttering severity. It is interesting to note that the two participants who were able to control their speech rates best after training were the two participants who were in the mild range of stuttering severity. Participants 1 and 2 were both in the mild range of stuttering severity, while participants 4, 5, and 6 were moderate, and participant 3 was severe. This study's original experimental design of three groups, with experimental condition randomly assigned, was to have controlled for stuttering severity by stratifying the experimental sample. This meant that before the experimental condition was assigned, participants were to be placed in three groups, mild, moderate, or severe, depending on their stuttering severity. When experimental condition was randomly assigned, it was to occur equally among the three groups, helping to prevent an unequal amount of any one level of stuttering severity from being assigned to any one experimental condition. Although the single subject design that this study evolved into did not allow for random assignment or stratification of the experimental sample, the design did allow for the observation of any effect that may have occurred due to stuttering severity. Unfortunately, with such a limited sample size, a conclusion cannot be made concerning the effect of stuttering severity on speech rate control. The possible connection raised by this research does suggest further research is warranted.

Perhaps the most important variable that may affect speech rate control ability suggested by this research is length of training time. The use of high school students during the school day for this study precluded lengthy training sessions. The time allotted for each training session under DAF or periodic visual feedback was approximately 30 minutes. The answer to the question of why two participants were able to transfer speech rate control ability from the training phase to the testing phase may lie in the amount of time that was allotted for training. It is possible that there are individual differences in the amount of time it takes individuals to establish speech rate control ability. If the results for all participants are considered, perhaps the data on speech rate control ability that were collected after approximately 30 minutes of time represent the mastery level that each participant had achieved on a speech rate control ability continuum. If participants were allowed to continue training in 30 minute increments, there may have been a point where all would have reached the speech rate control criteria. In retrospect, the training time variable seems to be the most powerful factor that could be manipulated in order to optimize speech rate control ability.

An Insight Into DAF as a Training Method

When the speech rate trends for both DAF and periodic visual feedback are examined, information is provided that confirms some assumptions that were made concerning periodic visual feedback training, and also provides an insight into DAF training. Figure 19, representing periodic visual feedback training, shows an average speech rate of 208 syllables per minute (spm) and a range of 144 spm for all participants on the first of 20 training readings. This was expected, as the participants did not receive feedback on their speech rates until after the first training reading. As training progressed, speech rates funneled downward toward the slowed speech rate goal of 155 spm to the final average speech rate of 162 spm and range of 52 spm for all participants on the final training reading. This downward progression was expected, as speech rates naturally began higher, and then lowered as participants adjusted their speech rates according to the visual feedback they received on speech rates after each reading. Figure 18, representing DAF training, provides an unexpected insight. It was thought that since participants received feedback throughout each reading of the test paragraph, they would maintain a consistent speech rate from beginning to end of the training phase. What actually occurred was similar to the periodic visual feedback condition, but in the opposite direction. Although all participants did begin with a tighter range in speech rates for the first of 20 DAF training readings than they did during periodic visual feedback training, there was an unexpected upward progression in speech rates toward the goal rate of approximately 155 spm. The range of speech rates was 58 spm for the first of 20 readings for all participants during DAF training. This is close to the range of 49 spm for all participants on the final DAF training reading, suggesting a consistency in speech rate throughout training for all participants; but there is a noticeable upward trend from an initial average speech rate of 120 spm to a final average speech rate of 160 spm for all participants during DAF training. This upward trend can be explained if the nature of DAF speech rate training is re-examined. Originally, it was felt that participants would require a short period of time before the DAF training phase to become accustomed to the DAF echo effect and learn how to properly prolong speech in order to overcome this effect. This proved to be the case, as all participants required some level of instruction during the five minute familiarization phase with DAF before they were comfortable with prolonged speech. It is now apparent that the upward progression in speech rates during DAF training reflects the true nature of DAF as a rate trainer. Instead of immediately falling into a consistent speech rate throughout all training readings, participants were continually adjusting their speech rate upward toward a maximum speed that would allow them to continue to be paced by the DAF delay without experiencing any echo effect. In retrospect, it was observed that participants initially adopted a slower than needed speech rate that achieved the purpose of pacing, and then continued to increase their speech rate from reading to reading until they reached the point where DAF produced an echo.

Clinical Implications

This study suggests that both DAF and periodic visual feedback may be effective training methods in establishing speech rate control in persons who stutter. Periodic visual feedback has been successfully used in the past and is presently being used to train speech rate in people who stutter (Sacco, 1996; Webster, 1972). In contrast, DAF has not been used solely as a speech rate training device. It has generally been linked with its ability to reduce stuttering

In fact, the tremendous fluency enhancing effects of DAF have largely relegated it to an all or nothing instrument in stuttering therapy. As was discussed in the introduction of this study, if DAF could be viewed as an instrument that is useful for the training of reduced speech rate with the benefit of fluency enhancement as a bonus, it could prove useful in a stuttering treatment program that combines proven elements of fluency enhancement in a multi-faceted approach. Participant 3 is an excellent example of an individual who could benefit from DAF if it was implemented as part of an overall stuttering treatment program. Participant 3 was unable to complete this study because his stuttering while reading was so severe that he could not take advantage of the periodic visual feedback training method. His speech rate was not fast enough to be able to approach the target speech rate of 155 spm, mainly because the adaptation effect of reduced stuttering over repeated readings was not evident in his case. When participant 3 experienced reading under DAF with prolonged speech, his stuttering frequency dropped noticeably. If he were to use DAF early in a stuttering treatment program, he might be able to immediately benefit from the reduced speech rate training ability of DAF that this research has suggested. Even persons who do not stutter severely could take advantage of early speech rate training in stuttering reduction programs using DAF. Rate training has been saved until the latter portions of stuttering treatment programs to allow participants to maintain consistent speech rates without the interruption of stuttering moments (Perkins, 1973; Sacco, 1996; Webster, 1972). Early intervention and increased time with speech rate training could increase a person's chances of being successful in transferring a consistent, reduced speech rate from the clinic to everyday speaking situations.

Advantages of the Single Subject Design

When the experimental design for this study had to be modified from a three group true experiment to a single subject quasi-experiment, it was originally felt that the lack of random assignment to condition and small sample size that resulted would be detrimental to internal and external validity. Although it is true that the small sample size severely restricts the ability to generalize the findings of this research from the sample to the population of people who stutter, the single subject design appears to have successfully controlled for the variable of training effect. This is apparent, since none of the participants displayed an increased speech rate control ability from one experimental condition to the next. In fact, the design itself lends itself to further study of some other variables that may be important in speech rate control, such as individual predisposition and preference for training method. In addition, a recent study by Ingham, Mongolia, Frank, Ingham, and Cordes (1997) lends further support to the use of single subject designs in research involving altered auditory feedback with people who stutter. In their research, four participants were placed under frequency altered feedback (FAF). FAF is similar to DAF, except when a participant speaks into a microphone, speech is raised or lowered one octave before it reaches the ears. The purpose of the study was to evaluate the fluency enhancing effect of $\pm$ one octave of FAF on stuttering frequency. The researchers discovered that FAF had a variable effect on fluency, and they contributed much of their findings to the strength of the single subject design in being able to determine within-subject differences that may have been obscured by the use of a larger sample size in a group design.

Areas For Further Research

The areas that appear ripe for further investigation of speech rate control training include most of the variables mentioned earlier that may contribute to speech rate control ability. Specifically, they are the predisposition for an auditory or visual learning style, motivation or preference for training method, training time, and stuttering severity. Ideally, a series of studies could be designed to assess each of these variables.

Future research could begin by investigating the possible relationship between learning style and preference for speech rate training method. A repeated single subject design similar to this study, involving both DAF and periodic visual feedback as speech rate training methods, could reveal an inherent predisposition toward DAF (auditory learning) or periodic visual feedback (visual learning) in individual participants. A component of the study, such as a post-experiment questionnaire, could be administered to determine participant preference for speech training method. The preference for training method could then be correlated with performance after training to determine if there is a positive relationship between a participant's rate control ability, possibly based on learning style, and preference. An additional component of the study could further investigate the possible correlation between performance with DAF and periodic visual feedback and learning style. This could be assessed by comparing participant performance with DAF and periodic visual feedback with results on psychological instruments that assess learning style. This could confirm that auditory learners perform better after DAF training and visual learners perform better after periodic visual feedback training. The proposed study would have to involve a larger sample size in order to get a wide representation of individual differences and predispositions.

If a positive correlation was found between superior ability with a particular speech rate training method and preference for that method; or between psychological learning style and training method, the information could be used to select a training method that was best suited for each individual. This information could then be incorporated into other studies that assess optimal training time to achieve speech rate control under either DAF or periodic visual feedback. These studies could be single subject, time series designs in which participants receive the training method best suited to them. The studies would include regular intervals of training and testing to determine the amount of time that is required to establish speech rate control within a specified criterion. The information from these studies could then be used as a reference for the average amount of training time that is required for effective speech rate control using DAF or periodic visual feedback.

Another aspect of training time is the amount of time the training effect lasts before speech rate control ability drops below a specified criterion. The one week break in between training sessions used in this research to control for training effect demonstrated that the speech rate control gained from training lasted less than one week. This was evident, since no participant was able to improve speech rate consistency from one control phase to the next. The length of time speech rate control lasts could be studied using the same research design that was used to investigate the length of training time needed to develop speech rate consistency. The study would include regular test periods following the completion of speech rate training until speech rate control fell below a specified criterion. This could demonstrate an average time that speech rate training lasts, and in conjunction with average training time to proficiency information, suggest a training schedule that people who stutter could maintain in order to optimize speech rate control ability.

An additional study investigating stuttering severity could use a single subject design that would train speech rate with the same procedure for all participants. Speech rate training would be with either DAF or periodic visual feedback, in order to control for any possible effect caused by preference for a particular training method. The study would look for a correlation between stuttering severity and speech rate control ability. Again, a larger sample size would be needed to incorporate enough variability in possible preference for training style to control for that variable.

The purpose of the present study was to investigate the rate control training abilities of DAF and periodic visual feedback, and to attempt to determine which method was better at consistently controlling speech rate among people who stutter. The results of the study do not support the research hypothesis that DAF may be a better speech rate training method than periodic visual feedback. However, they do suggest that both methods may be effective. The results further suggest that there may be other variables that affect the ability to control speech rate, and they may be based on individual learning styles, preference for training method, training time, or stuttering severity. DAF deserves further investigation as a viable speech rate training component in a multi-faceted approach to the treatment of stuttering. Its ability to produce fluent speech in people who stutter has overshadowed the speech rate training properties that this research suggests.

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Appendices

Appendix A. Stuttering Etiology Questionnaire

Participant Questionnaire

Name:

1. What age did your speech difficulty begin?
2. Did it happen gradually or suddenly?
3. Has your speech difficulty gotten better or worse at different times?
4. Did you have any other physical or mental difficulties when your speech difficulty began?
5. Have you ever had a significant head injury that has required medical attention?
6. Were you born with any type of neurological disease or disorder? i.e: spina bifida, cerebral palsy, etc.
7. Have you been diagnosed with a neurological disease since birth? i.e.: multiple sclerosis, parkinsons disease, etc.
8. Have you ever had a stroke?
9. Have you ever been treated with medication for seizures, anxiety, depression, or schizophrenia?

Appendix B. Speech Rate Training and Testing Paragraph

A Camping Tale

Soon after May had caught the fish, she realized she was alone. She yelled until she almost lost her voice. But no one answered. She was lost. And there was no one to point the way. Her camping trip had become a nightmare.

“I might not enjoy it,” she thought, “but I guess I'll have to make it alone. I don't have any other choice!”

At first, May jumped at every noise in the woods. But soon, she got used to the noises.

May was very hungry. That made her think about the coin purse in her pocket. But the coins might have been toy money. They wouldn't buy any food in the woods. At least she had a sleeping bag and a few supplies. She would be all right.

“The first thing I'll do,” she thought, “is build a fire. Then I'll boil water for cocoa. I don't have any oil to fry the fish. I'll have to broil the fish I caught. I'll cook a royal feast!”

Appendix C. Authorization for Use of Test Paragraph

3631 Yardley Ave. N
St. Petersburg, FL 33713
February 16,1998

Copyright Permissions
Steck-Vaughn Company
P.O. Box 26015
Austin, TX 78755

Copyright permission personnel:

I would like to utilize the first page of the story "A Camping Tale" located on page 152 in Steck-Vaughn spelling book ISBN: 0-8114-4105-9, copyright 1990.

The passage will be used in a research project where participants will read the passage repeatedly in order to test a hypothesis on rate training in people who stutter. The experimentation for the research will be conducted at the University of South Florida between August and December of 1998.

Permission to reproduce this passage and use it in the manner described above would be greatly appreciated. If any further information is needed, such as a copy of the proposal for the intended research, I can be contacted at (813) 328-2806, or the above address. Thank you for your attention to this matter.

Sincerely,

Russell G. Boyce
Graduate Student
Speech Language Pathology
University of South Florida

2-26-98

Permission to copy GRANTED
as so stated in your letter.
This material cannot be sold
for profit.

Carey [illegible]. Collier
Steck-Vaughn Company

Appendix D. Studder Computer Program Specifications

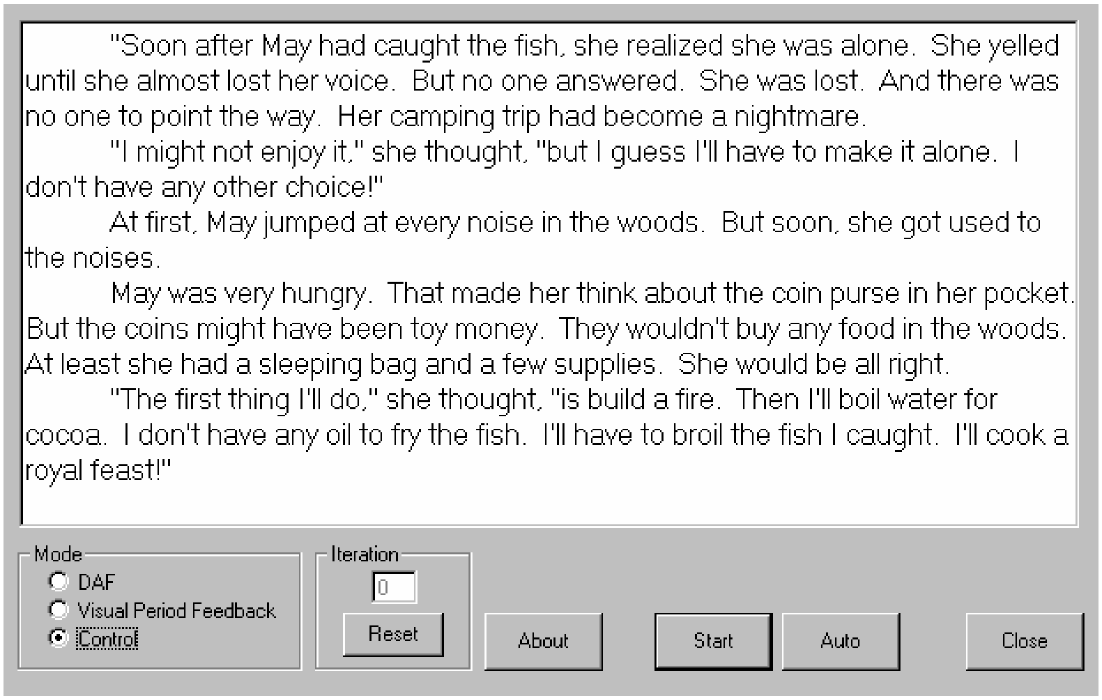

Figure 20. Computer screen image of the Studder Computer program.

Studder was created by Steven Boyce using visual basic. The program was originally developed to create a way for participants to have their speech rate paced at 155 syllables per minute (spm) while reading the test paragraph. It later blossomed into a full featured application and was teamed with a laptop computer to achieve greatest utility and portability.

The Studder program included the ability to select one of three modes: Control, DAF, or periodic visual feedback, which corresponded with the conditions of the experimental procedure. The program was also able to highlight the test paragraph syllable by syllable, display speech rates in syllables per minute, and save speech rate data for all readings of the test paragraph.

Figure 20 shows Studder as it appeared to participants on a computer screen. In the lower left corner is the mode selection feature, which allowed control, DAF, or periodic visual feedback mode to be chosen. Each participant began in control mode. When the auto button in the lower right hand corner of the screen was depressed, each syllable of the test paragraph was highlighted at a rate of 155 (spm) as the participant read along. Five more readings of the test paragraph took place in control mode. The participant depressed the start/stop button in the lower middle portion of the screen immediately before and after each reading. This action automatically recorded the speech rate, with stuttering moments, for each reading of the test paragraph. As each reading was completed, the participant and researcher were able to look at the iteration window in the lower middle part of the screen, and determine how many readings of the test paragraph had been completed. At the end of a control session, the program would automatically save all of the speech rates for later analysis.

The speech rate display feature was active in the periodic visual feedback mode. Each participant trained for 20 readings of the test paragraph, depressing the start/stop button before and after each reading. The program not only recorded speech rates, but also displayed the rate of each reading in a pop-up window. This allowed participants to modify their speech rate in-between readings to achieve the goal rate of 155 spm. After training, five test readings followed, with no speech rate displayed between readings. The periodic visual feedback mode also allowed the speech rates of all readings to be saved and later displayed in report form.

DAF mode functioned the same as periodic visual feedback mode, except that none of the speech rates were reported back to the participants. They had to rely on the DAF pacing in order to maintain a consistent speech rate. As in the control and periodic visual feedback modes, all speech rates were recorded and saved with the ability to later generate a report of speech rates for each DAF trial

Appendix E. Child's Informed Consent for Research

Child's Informed Consent
University of South Florida

Information for People Who Take Part in Research Studies

The following information is being presented to help you/your child decide whether or not your child wants to be a part of a research study. Please read carefully. Anything you do not understand, ask the researcher, Russell Boyce.

Title of Study:	An Investigation of Delayed Auditory Feedback in Speech Rate Control.
Principal Investigator:	Russell Boyce, Graduate Student USF - Communication Sciences and Disorders Department.
Co-investigators :	Elizabeth Kaplon, Ph.D., Robert Dedrick, Ph.D., Mark Witkind, Ed. M.
Study Location(s):	University of South Florida CSD, West Central Florida High Schools.

General Information about the Research Study

The purpose of this research study is to investigate the relative effectiveness of rate control training methods used for persons who stutter. The two methods of rate training under investigation are periodic visual feedback, and delayed auditory feedback. Periodic visual feedback occurs when a subject's speech rate is visually shown at regular intervals in order for the subject to be able to modify speech rate to reach a goal rate. Delayed auditory feedback is created when the subject speaks into a digital delay unit that creates a delay (echo effect) of a prescribed number of milliseconds. The subject then attempts to slow speech rate in an effort to turn the delay effect into one that creates a pacing effect on speech rate.

The number of other people that might take part in this study is: 30-45

Appendix E. (Continued)

Research Procedures involved

- Administration of a hearing screening.

- Administration of a standardized stuttering severity instrument while being audio and video taped. All audio and videotaping is for diagnostic purposes only. Length of audio and video taping will be approximately 30 minutes per subject. Safeguarding and access to audio and videotaped samples is described below in confidentiality of records.

- Reading of a 197 syllable paragraph multiple times. Approximately 5-10 paragraphs per subject will be audio recorded for speech rate analysis.

- Total participation time: Approximately two one hour sessions.

Benefits of Being a Part of this Research Study

- Potential benefits of this study for you and your child include receipt of the final results of the research for potential use in future fluency management, and helping to increase the overall knowledge of the disorder of stuttering, which may be used to help others with this disorder.

Risks of Being a Part of this Research Study

- There are no notable risks involved in participation.

Alternatives of Being Part of this Research Study

- If you choose not to participate in this study but are interested in learning more about the USF Communication Sciences and Disorders Department, please call the clinic coordinator at (813) 974-2006.

Payment for Being a Part of this Research Study

- You nor your child will receive any cash or other benefits for taking part in this research study.

Appendix E. (Continued)

University of South Florida Injury Statement

- In the event that you sustain an injury or illness as a result of participating in this research, please by aware that medical treatment for the injuries or illness may not be available from the University of South Florida (USF). USF does not maintain an emergency department nor does it provide medical treatment in all disciplines of medicine. If you become ill or sustain an injury which you believe is related to participation in this research, immediately contact one of the persons listed on page 1 of this form, and if emergency care is needed seek emergency attention from your nearest local hospital.

  If injury results from your participation in research, money damages are not automatically available. Money damages are only available to the extent specified in Florida statute, 768.28. A copy of this statute is available upon request to the Division of Sponsored Research, USF. This statute provides that damages are available only to the extent that negligent conduct of a University employee caused your injuries, and are limited by law. If you believe you are injured as a result of participation in this research and the negligent conduct of a University faculty member, you may notify the USF Self Insurance Programs Office at (813) 974-8008, who will investigate the matter.

Confidentiality of Your child's Records

- Your child's research records will be kept confidential to protect your child's privacy to the full extent of the law. Any data or information reported on your child will not mention your child by name. Each child will be given a subject code number for reference. All audio and video tapes used for diagnostic purposes will be stored securely in a locked cabinet on the second floor of the Behavioral Sciences Building at USF. Audio and video tapes will be kept only until diagnostic evaluation is completed on or before December 31, 1998. At that time, they will be erased and discarded. However, authorized research investigators and the USF Institutional Review Board may inspect the records from this research project.

- The results of this research study may be published, but they will not include your child's name or any other information that may identify your child.

Appendix E. (Continued)

Volunteering to Be Part of this Research Study

- Your child should only take part in this research study if your child wants to. If your child decides he/she wants to stop taking part in the study, there is no penalty for withdrawal.

Questions and Contacts

- If you or your child have any questions about this research study, contact Russell Boyce at (813) 328-2806, or Elizabeth Kaplon, Ph. D., at (813) 974-9792.

- If you or your child have questions about your child's rights as a person who is taking part in a research study, you/your child may contact a member of the Division of Compliance Services of the University of South Florida at (813) 631-4498.

Child Consent—By signing this form I agree that:

- I have fully read or have had read and had explained to me in my native language this informed consent form describing a research project.
- I have had the opportunity to question one of the persons in charge of this research and have received satisfactory answers.
- I understand that my child is being asked to participate in research. I understand the risks and benefits, and I freely give my consent to have him/her participate in the research project outlined in this form, under the conditions indicated in it.
- I have been given a signed copy of this informed consent form, which is mine to keep.

______________________________	____________________	_____
Signature of Parent of Participant	Printed Name of Parent	Date

- I would / would not (please circle) like to receive the researcher's (Russell Boyce) results and conclusions of the above study. Please write mailing address at the bottom of this form if results and conclusions are desired.

Appendix E. (Continued)

Child's Assent Statement

Mr. Russell Boyce ______________________, has explained the research study called: An Investigation of Delayed Auditory Feedback in Rate Control Training to me. I agree to be in this study.

Signature of Child's	Printed Name of Child's	Date
Signature of Parent	Printed Name of Parent	Date
Signature of Investigator	Printed Name of Investigator	Date
Signature of Witness	Printed Name of Witness	Date

OR

(Insert name of child's here.) ______________________ is unable to give assent for the following reason(s):

Signature of Parent	Printed Name of Parent	Date

Appendix E. (Continued)

Signature of Investigator	Printed Name of Investigator	Date

Signature of Witness	Printed Name of Witness	Date

Investigator Statement

I have carefully explained to the subject the nature of the above protocol. I, hereby, certify that to the best of my knowledge the subject signing this consent form understands the nature, demands, risks and benefits involved in participating in this study and that a medical problem or language or educational barrier has not precluded a clear understanding of the subject's involvement in this study.

Signature of Investigator	Printed Name of Investigator	Date

Institutional Approval of Study and Informed Consent

This research project/study and informed consent form were reviewed and approved by the University of South Florida Institutional Review Board for the protection of human subjects. This approval is valid until the date provided below. The board may be contacted at (813) 631-4498.
Approval Consent Form Expiration Date: *(Stamp date here.)*

Revision Date:________________

Appendix F. DAF Condition Script

DAF Condition Script

We will begin by reading the paragraph displayed on the monitor a few times. Read as you would normally read any material.

(Five recitations of the paragraph completed)

Next you will read the paragraph at the same rate that the computer highlights the syllables on the screen. You don't have to read each syllable exactly when they are highlighted by the computer. Just read along and use the highlighting as a guide for how fast you should be reading.

Now you will read the displayed paragraph a few more times. Place the mouse arrow on the start button and click the left mouse button when you begin reading the paragraph. Click the stop button with the mouse when you finish reading the paragraph. You will click the start stop button every time you read the paragraph. Try to read each paragraph at the same speech rate that you used when you were following along with the computer. Don't forget to click the start stop button before and after each reading. You may pause for a moment between readings if you like.

(Five recitations of the paragraph completed)

Next we will spend a few minutes getting used to the delayed auditory feedback machine. You will be placing the headphones on your head and speaking into the boom microphone. I will be listening in on another headset while we practice. What you will hear is an echo effect that will delay the speech coming from your mouth before it reaches your ears. Do not attempt to fight the effect. I would like you to prolong your speech and attempt to make what is coming out of your mouth match what you hear in your ears.

(Demonstration of prolonged speech).

There is a point where you can slow your speech just enough so that the speech you produce will match exactly with what you are hearing. Try to keep your speech just slow enough to create this matching effect, but not fast enough to hear any echo. Also, try to make your speech sound as natural as possible under the delay.

(Demonstration of natural inflection vs. monotone under DAF).

(Approximately five minutes of practice reading with researcher monitoring and providing feedback)

Now you will read the displayed paragraph a number of times while under delayed auditory feedback. Try to maintain the same matching effect throughout all of your reading. Don't forget to click the start stop button before and after each reading. You may pause for a moment between readings if you like. This training phase will take approximately 30 minutes.

(20 recitations of the paragraph completed)

Now I would like you to read the paragraph a few more times without the delayed auditory feedback. Try to maintain the same speech rate you have been using.

(Five recitations of the paragraph completed)

Appendix G. Periodic Visual Feedback Condition Script

Periodic Visual Feedback Condition Script

We will begin by reading the paragraph displayed on the monitor a few times. Read as you would normally read any material.

(Five recitations of the paragraph completed)

Next you will read the paragraph at the same rate that the computer highlights the syllables on the screen. You don't have to read each syllable exactly when they are highlighted by the computer. Just read along and use the highlighting as a guide for how fast you should be reading.

Now you will read the displayed paragraph a few more times. Place the mouse arrow on the start button and click the left mouse button when you begin reading the paragraph. Click the stop button with the mouse when you finish reading the paragraph. You will click the start stop button every time you read the paragraph. Try to read each paragraph at the same speech rate that you used when you were following along with the computer. Don't forget to click the start/stop button before and after each reading. You may pause for a moment between readings if you like.

(Five recitations of the paragraph completed)

Now you will read the displayed paragraph a number of times using periodic visual feedback. Each time you read the paragraph, a window will pop up and tell you your speech rate in syllables per minute. Try to get as close to

Appendix G. (Continued)

155 syllables per minute as you can. If your speech rate is higher than 155 syllables per minute, read the paragraph more slowly next try. If your speech rate is below 155 syllables per minute, read the paragraph faster the next try. Don't forget to click the start stop button before and after each reading. You may pause for a moment between readings if you like. This training phase will take approximately 30 minutes.

(20 recitations of the paragraph completed)

Now I would like you to read the paragraph a few more times without the periodic visual feedback. Try to maintain the same speech rate you have been using.

(Five recitations of the paragraph completed)

Appendix H. U.S.F. Institutional Review Board Research Proposal Approval

University of South Florida USF

September 8, 1998

Russell G. Boyce
3631 Yardley Ave. North
St. Petersburg, FL 33713

Dear Mr. Boyce,

Your new protocol (**IRB #98.259**) entitled,

"An Investigation of Delayed Auditory Feedback in Speech Rate Control

Including the informed consents has been approved under expedited review category #9. This information shall be presented to the Board at its next convened meeting. You should take special note of the following:

- Approval is for up to a twelve-month period. A Research Progress Report to request renewed approval must be submitted to this office ***by the submission deadline in the eleventh month of this approval period***. A final report must be submitted if the study was never initiated, or you or the sponsor closed the study.
- Any changes in the above referenced study may not be initiated without IRB approval except in the event of a life-threatening situation where there has not been sufficient time to obtain IRB approval.
- All emergency uses of a test article must be reported to the IRB within five (5) working days of occurrence.
- All changes in the protocol and informed consent must be reported to the IRB.
- If there are any adverse events, the Chairperson of the IRB must be notified immediately in writing.

If you have any questions regarding this matter please do not hesitate to call me at 631-4498.

Sincerely,

APPROVED UNTIL
AUG 31 1999
USF(?) INSTITUTIONAL REVIEW BOARD

Submit your Research Progress Report by the submission deadline One month prior to the above date. Failure to meet this deadline will Result in closure of the study.

Richard F. Walker, Ph.D.
Director

RFW: amr
cc: FAO

Office of Research, Division of Compliance Services
Institutional Review Boards, MPA No. 1284-01XB/M1284-02XM
University of South Florida • 10770 North 46th Street, Suite C-200 • Tampa, Florida 33617-3465
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Appendix I. U.S.F. Institutional Review Board Change in Procedure Approval

University of South Florida
USF

October 30, 1998

Russell G. Boyce
3631 Yardley Ave. North
St. Petersburg, FL 33713

Dear Mr. Boyce,

Your change in procedure **[IRB# 98.259]** for your protocol entitled,

"An Investigation of Delayed Auditory Feedback in Speech Rate Control"

included the following changes:

- Revisions/modifications to the protocol, dated October 10, 1998.
- Changing the experimental design from three groups of 10+ participants to be recruited, representing the control and two experimental conditions, to one group including a control and two experimental groups to one that is of an AB design. This will allow for the testing of each participant as they are recruited, with a delay in between treatment conditions, to control for training effect. There will be no change in the requirements for participation in the study, including time requirements, which will require no change in the current informed consent forms.

These changes were approved by the Institutional Review Board under expedited review. This action will be reported at the next convened IRB-02 meeting on 11/13/1998

If you have any questions or comments please telephone me at 631-4498.

Sincerely,

Richard F. Walker, Ph.D.
Director

RFW: amr

Office of Research, Division of Compliance Services
Institutional Review Boards, MPA No. 1284-01XB/M1284-02XM
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