THE EFFECTS OF VARYING RHYTHMIC STIMULUS ON AND OFF DURATION ON
STUTTERING FREQUENCY AND SPEECH NATURALNESS

by

ROBIN SELMAN

(Under the Direction of Anne Marcotte)

ABSTRACT

This study investigated the effects of varying the duration of a rhythmic stimulus (its “on
time”) and the duration of the pauses between stimuli (“off time”) on stuttering frequency and
speech naturalness in adults who stutter. Three adult males with developmental stuttering served
as participants. Each participant produced monologues while timing his speech to 16 different
rhythmic stimulus conditions that varied on time from 0.1 s to 3 s and varied off time from 0.25 s
to 1.5 s. Stuttering frequency, listener-rated speech naturalness, and self-rated speech
naturalness were measured for each of the conditions. Results showed that stimulus on-time
duration was the greatest predictor of both stuttering frequency and speech naturalness. Off-time
duration seemed to have little to no effect on stuttering frequency or speech naturalness, for these
speakers and these durations. Implications for future research and for clinical applications are
discussed.

INDEX WORDS: stuttering; rhythm; speech naturalness
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CHAPTER 1
LITERATURE REVIEW AND STATEMENT OF THE PROBLEM

Introduction

The ability of rhythm to reduce or eliminate stuttering has long been known. L’Isere is credited with having described rhythmic speech in 1831 (Van Riper, 1971), but there are even earlier reports of rhythm’s effect on stuttering. Demosthenes, a Greek orator who stuttered, practiced speaking while walking uphill. It is theorized that his walking helped him speak in a rhythm (Van Riper, 1973). Modern research documenting the effectiveness of rhythmic speech began with Johnson and Rosen’s (1937) work that compared rhythmic speech to normal speech. Eighteen persons who stutter (PWS) were prescribed several different speaking patterns, including whispering, singing, and chorus reading. Comparisons were made between the participants’ stuttering rates using their normal speech pattern and stuttering rates using the prescribed speech pattern. Results showed that PWS produced 0.06% words stuttered when speaking with a metronome as compared to 7.6% words stuttered using their normal speech pattern.

This general finding that PWS produce less stuttering when using a rhythmic pattern has been consistently replicated in later work (reviewed in the following sections). Despite its ability to assist the speaker in producing nonstuttered speech, however, rhythmic speech is often disregarded as a treatment strategy because it results in unnatural sounding speech. The following sections will review rhythm research, discuss the naturalness problem, and discuss the rationale behind the present study.
The Effect of Rhythm on Stuttering

There is substantial evidence about the effects that rhythm has on those who stutter. A landmark study by Johnson and Rosen in 1937 examined the effects on stuttering of several different speech patterns. In the study, 18 PWS were asked to read different 500-word passages while using several different speech patterns, including whispering, singing, fast and slow rates, and reading along to a metronome. During regular reading conditions, PWS produced between 3.5 and 7.6% words stuttered. When reading along to a metronome, mean words stuttered dropped to 0.06%.

In 1950, Bloodstein surveyed 204 PWS, ages 16 to 44, to examine their opinions on activities that may reduce stuttering. Responses were categorized into such areas as reduced need to make a favorable impression, changes in speech pattern, and minimum negative reaction to stuttering. Several of the activities were rhythmic, including foot tapping, speaking with a rhythmic twist of hand from wrist, and walking. He found that 92% of respondents reported that they stuttered “hardly…at all” or “never” (p. 32) when speaking in time with the rhythmic swing of their own arm.

A third example comes from Azrin, Jones, and Flye (1968), who examined the effects of a vibrotactile rhythmic stimulus on stuttering behavior. Four male college students were participants for the study. The stimulus was presented via a band worn on the wrist that contained a bone conductor, which was placed upon the bony projection of the wrist. A vibrating pulse was delivered at the rate of 90 pulses per minute (min). The first participant had a baseline speech rate of 70% words stuttered, while the other participants each had baseline speaking rates of between 16 and 30% words stuttered. With the vibrotactile stimulus presented at 90 pulses/min during reading, the first participant was able to reduce stuttering to a rate of 8%
of words stuttered. The other three participants were able to reduce stuttering to between zero and 2% words stuttered.

Finally, Andrews, Howie, Dozsa, and Guitar, in 1982, collected speech samples from 3 adult male PWS under 15 conditions that were thought to increase fluency. One such condition was syllable-timed (or rhythmic) speech. After practicing with a metronome for 15 min, each participant spoke for 10 min on various topics. Using syllable-timed speech, two of the three participants completely eliminated their stuttering, from a baseline speech rate of 22.0% syllables stuttered for one participant and 6.3% syllables stuttered for the second. The third participant was able to reduce stuttering from 19.0% syllables stuttered at baseline to 4.1% syllables stuttered with the syllable-timed speech. Overall, the reports discussed above and many others (see Bloodstein & Ratner, 2008; Ingham, 1984) are consistent in demonstrating that many different rhythmic stimuli can reduce stuttering. Given this consistent effect, one reasonable question that might emerge is whether rhythm can be used as a treatment for stuttering.

*Rhythm Treatments for Stuttering*

Most reviews trace the emergence of rhythm as a treatment for stuttering to a report in 1940 by Van Dantzig (Ingham, 1984), who used a finger-tapping technique as part of a behavioral therapy (Van Dantzig, 1940). The method consisted of three levels of training. The first level involved teaching the participant to tap successive fingertips in line with each syllable. After mastering the process, the participant would then be taught to control his/her stuttering by manipulating the tapping of a finger. After the student had learned to control stuttering with the finger tapping technique, he/she then reduced the movement of the finger tap, making it more of an impulse than an actual movement.
A study by Andrews and Harris in 1964 (described by Ingham, 1984) not only examined the use of syllable-timed speech as a therapeutic technique, but also set forth a structure and method for behavioral therapy that has been the basis of many other therapy programs. For this study, the experimenters divided the participants into four different groups based on age, with two adult groups, one of adolescents, and one of children. Each group received intensive therapy for 10 hours each day for 10 days, during which they were educated on the use of syllable-timed speech, and then able to practice the technique using oral readings and conversation. Following the initial intensive treatment program, participants returned weekly for 1-hour practice sessions. Speech data collected during the experiment, before and after the intensive sessions and then again at 6-, 9- and 12-month follow-ups, included the percentage of words stuttered and words spoken per min. Results showed that the children’s group was most successful in reducing stuttering rate. Before treatment, children had an average of 20.4% words stuttered. At the 9-month follow-up, stuttering had been reduced to 0.8% of words. However, results from the adolescent and adult groups showed that they did not significantly reduce their percentage of words stuttered during follow-up evaluations, a problem of maintaining treatment gains that is often evident in stuttering. In addition to the maintenance of treatment gains, rhythmic treatments for stuttering also brought to light the issue of the resulting unnatural sounding speech.

Naturalness

Despite its ability to reduce stuttering, one of the problems with rhythm is that it often results in unnatural sounding speech. Indeed, in general terms, judgments of the naturalness of speech have for decades been an important part of research regarding stuttering, as many
treatment methods often eliminate stuttering, but leave the speaker with unnatural sounding fluent speech (Martin, Haroldson, & Triden, 1984). Several methods of measuring naturalness have been used, both by listeners and the speakers themselves.

One method for measuring naturalness, in the context of rhythmic speech, was demonstrated in 1969, when Jones and Azrin attempted to address the unnatural sounding results of traditional rhythmic speech. They investigated the effects of lengthening the duration of the individual stimulus beats, and therefore increasing the amount of speech per beat, while keeping the stimulus-off duration constant. Four male college students, ages 19-25, served as participants for the study. Stimuli for the experiment were presented as vibratory pulses on the wrist of the participant. Participants were presented with the vibratory stimulus in durations varying between 0.1 and 300 seconds (s), with a constant stimulus-off duration of 1 s. For this experiment, stuttering was defined as “an abnormal prolongation, interruption, or repetition of a part of a word or a repetition of a whole word” (p. 224). Results of the experiment showed that, as would be expected, stuttering was reduced with the rhythmic stimulus. Stuttered events remained near zero for all participants up until the length of the stimulus-on duration was 1 s. In addition, ratings of speech naturalness increased as the stimulus-on duration increased, up until the point that stuttering returned (1-2 s stimulus duration).

In 1994, Finn and Ingham expanded on the work of Jones and Azrin by further examining the speech naturalness of PWS speaking to rhythmic stimuli of varying durations. Twelve adult PWS participated in the experiment. Seven rhythmic stimulus patterns were used, based on Jones and Azrin’s work. Stimulus-on duration varied from 0.1 to 5 s, with the stimulus-off duration set at a constant 1 s. Data showed that stuttering increased as stimulus-on duration
increased, from near zero stutters at 0.5 s to closer to 1 stutter per trial at 3 s. Self-ratings of speech naturalness were similar to those found by listeners in the Jones and Azrin study. Perkins, Rudas, Johnson, Michael, and Curlee (1974) used a much more elaborate method of rating naturalness in their study of two behavioral methods of managing stuttering. In the first method, rate control (delayed auditory feedback) was used as a means to shape fluency. In the second method, the focus was on breathstream, phrasing, and prosody as well as fluency. Based on their clients’ complaints about the speech resulting from previous attempts to attain fluency, Perkins et al. sought to improve the naturalness of participants’ fluent speech patterns. Most notable were complaints of lack of normal rate, and lack of expressiveness. Therefore, Perkins et al. created 4-point rating scales measuring separately fluency, rate, and prosody. Fluency was rated from “severe stuttering or stammering” to “exceptionally fluent,” rate was rated from “extremely slow” to “extremely fast,” and prosody was rated from “extremely monotonous” to “extremely expressive.” Listeners in the study were not given any training or information regarding criteria for each of the characteristics. However, high interjudge reliability scores, with correlations ranging from 0.85 to 0.94, show that the listeners were consistent in their findings. Results showed that the second group, which focused on other characteristics of speech besides fluency, were judged to speak significantly more fluently and faster than the group focusing on fluency alone. At a 6-month follow up, the speakers in group two were again judged to sound more similar to normal control speakers. Ingham and Packman (1978) then compared these two basic naturalness rating techniques (rating overall naturalness versus using more specific scales). They compared 9 normally fluent speakers with 9 PWS who had recently successfully completed a stuttering treatment program. All stuttering speakers produced speaking samples that were judged by two clinicians to be
stutterfree. Five different groups of listeners each completed one rating scale for the speech samples. The five scales were rate, prosody, fluency, natural/unnatural, and stuttered/normal. The results of this study showed that, while ratings of rate, prosody, and fluency were similar between the two groups, the group of stuttering speakers received significantly fewer judgments of being normal speakers. PWS who had undergone treatment achieved speech that was the same in many regards as that of normal speakers, but they still had some aspects of their speech that highlighted them as PWS.

In 1984, Martin et al. developed a scale of speech naturalness. It was a 9-point scale to be used by untrained listeners. To assess the effectiveness of the scale, the authors had listeners listen to 1-min speech samples from PWS, normal speakers, and PWS speaking with delayed auditory feedback (a fluency-inducing condition known to reduce stuttering, but at the expense of naturalness). Listeners heard the 1-min speech samples and were then asked to rate them on the scale. A rating of 1 was defined as “highly natural,” and 9 “highly unnatural.” A definition of naturalness was not provided to the listeners. To test interrater reliability, the listeners returned at least one week after their first session and repeated the task. Analysis of the listener judgments examined the extent to which raters agreed, and the consistency of raters judging the same speech sample of multiple occasions. The speech naturalness rating scale showed good interrater agreement, meaning that each judge independently rated the speech samples similarly. For all three groups, judges rated speech naturalness within +/- 1 scale value on 74-77% of the speech samples. The speech naturalness scale also showed good intrarater agreement, or the extent to which the judge gives a similar rating when viewing the speech sample on multiple occasions. For all three groups, judges rated speech naturalness within +/- 1 on 85-90% of the speech samples. Overall, Martin et al.’s study is generally credited with introducing a way to
measure speech naturalness that was found to be both consistent and reliable. It provided a sound basis for future research on stuttering therapy.

The speech naturalness rating scale developed by Martin et al. was soon put to use. In two studies by Ingham and Onslow in 1985, the experimenters not only added to the body of evidence supporting the validity of the instrument, but also showed how it could be used in therapy to address and improve speech naturalness. In one study, listeners were asked to use the rating scale to judge speech samples taken at various points in time as the stuttering participants were going through a prolonged speech therapy program. Judgments made by independent observers were shown to be similar, when visually analyzed, with those made by the listeners in the experiment, showing that the instrument is reliable for measuring speech naturalness. However, the results regarding reliability of the ratings made by untrained listeners were slightly more modest than those found by Martin et al. Martin et al. found 75.3% of naturalness ratings were within one scale point, while the Ingham and Onslow found 59.2% of naturalness ratings fell within I scale point of the original ratings. The authors therefore suggested the possibility that a training program be developed to help listeners learn to assign reliable and valid ratings to speech samples. Such a training program was developed as part of the Stuttering Measurement System training procedure (Ingham, Bakker, Ingham, Kilgo, & Moglia, 1999).

In summary, many variations on rhythmic speech have been used to reduce stuttering for centuries. Modern research has adapted these techniques as part of programmed treatment approaches, but the unnaturalness of the resulting speech remains a problem. The works of Jones and Azrin, and Finn and Ingham, suggest that alterations in the rhythmic pattern can alter the naturalness of the resulting speech, but the potential for substantially improved treatment methods suggested by those studies has never been explored. Specifically, the work started by
Jones and Azrin, and continued by Finn and Ingham, shows that use of a rhythmic stimulus can reduce stuttering even when stimulus-on time is extended beyond a single beat. Having more than one syllable per beat increases the naturalness of the speech, up until the point where stuttering returns. However, research up until this point has not considered the effect of varying the stimulus-off duration on speech naturalness and stuttering rate. This is an important aspect of any rhythmic speech pattern, especially because of the importance of pause time to normal speech.

Normal Speech Patterns

As the literature has shown, one of the main issues raised with rhythmic speech treatments is the resulting lack of natural sounding speech. Therefore, it is important to understand some of the characteristics of normal speech. One aspect of speech that can affect its overall naturalness is the duration of pauses. In 1961, Goldman-Eisler sought to determine the duration and distribution of pauses in normal speech. Nine participants were instructed to complete various speaking tasks, including describing or summarizing a cartoon, participating in a discussion, or participating in a structured psychiatric interview. To measure pause duration, audio recordings were transformed into visual recordings by the use of a pen-recorder connected to a tape recorder. The results were that, for spontaneous cartoon descriptions or summarizations, 63.4-71.5% of pauses had durations of less than 1 s. With discussions, adults had 87% of pauses with durations of 1 s or less. Almost 50% of pauses were less than 0.5 s.

In 2002, Logan, Roberts, Pretto, and Morey examined the effects of four different approaches to reducing adult speech rate. One of the main components of the study was to determine the effect the various approaches had on the naturalness of speech. Two separate
experiments were conducted. In the first experiment, 40 females participated, with 8 participants in each of the four experimental groups, and 8 participants serving as controls. The four experimental groups received training to slow their overall rate of speech by either reducing articulation rate (AR), increasing the number and duration of intra- and inter-utterance pauses (IUP), increasing the duration of turn-switching pauses (TSP), or by using a self-derived method of speech rate reduction (SDM). In addition, participants were asked to rate how natural it felt to use the particular speech-rate reduction technique on a scale of 1-7, with 1 being “very unnatural” and 7 being “very natural.” All participants were able to successfully reduce their speech rate. In the IUP group, the resulting average pause duration was 1.48 s, with the mean naturalness rating being 3.9, or falling close to “somewhat unnatural.” In the second experiment, listeners were asked to rate the naturalness of pre-and post-training speech samples from each of the experimental groups. Results showed that post-training speech samples from the AR, IUP, and SDM experimental groups were judged to sound significantly less natural than those from the control group. Without additional training, in other words, all introductions of pauses greater than about 1 s resulted in less natural speech.

The Present Study

The preceding sections reviewed previous research about the influence of rhythm and pauses on speech naturalness. Based on this information, a study was designed to investigate the effects on stuttering and speech naturalness of several variations on rhythmic speech patterns that varied both speaking time (or the time that the stimulus is on) and pause time (or the time that the speaking stimulus is off). The overall goal of this study was to determine whether certain
stimulus-on or –off durations would reduce stuttering and result in natural sounding speech.

Specific hypotheses included the following.

A) Predictions regarding stimulus-on duration

Hypothesis 1. Stimulus-on durations of greater than 1 s will result in more stuttering than stimulus-on durations of 1 s or less, regardless of stimulus-off duration.

Hypothesis 2. Stimulus-on durations of greater than 1 s will result in more natural sounding speech than stimulus-on durations of 1 s or less, regardless of stimulus-off duration.

B) Predictions regarding stimulus-off duration

Hypothesis 3. Stimulus-off durations of less than 1 s will result in more natural sounding speech than stimulus-off durations of 1 s or more, regardless of stimulus-on duration.

Hypothesis 4. Stimulus-off durations of less than 1 s will result in less stuttering than stimulus-off durations of 1 s or more, regardless of stimulus-on duration.

C) Predictions regarding interaction between stimulus-off and stimulus-on time

Hypothesis 5. Stimulus-on durations of more than 1 s combined with stimulus-off durations of less than 1 s will produce the most natural sounding speech.
CHAPTER 2

METHODS

Participants

Three males who stutter participated in this study. Participant AJ was 30 years old and reported stuttering since the age of 2. He had received therapy for his stuttering at several points in the past, most recently from 2006 until 2009 at The University of Georgia Speech and Hearing Clinic. He had never had treatment based on rhythmic speech, and he was not receiving therapy at the time that this study was conducted. His stuttering was rated as severe to profound by the experimenter and by another experienced speech-language pathologist. His speech was characterized by long blocks with obvious visual concomitants (e.g., open mouth, tongue protrusion). His speech in the 5 min of speech used to determine qualifications for this study displayed 24.82 percent syllables stuttered (%SS), 42.63 syllables per min (SPM), a naturalness rating of 8.25 for listeners, and a self-rated naturalness of 7.4 (all listener-judged data represent the mean of two judges; see details below).

Participant BW was 22 years old and reported stuttering since age 8. He is currently receiving weekly therapy at The University of Georgia Speech and Hearing clinic, with the focus of treatment being prolonged speech and gentle onsets. His stuttering was rated mild to moderate by the experimenter and other speech-language pathologist. His speech was characterized by syllable repetitions and short blocks, with no obvious concomitant physical features. His speech in the 5 min of speech used to determine qualifications for this study displayed 2.18 %SS, 195.26 SPM, a naturalness rating of 2.23 for listeners, and a self-rated
naturalness of 6. His low rate of stuttering, and his current treatment status, were initially accepted as meeting all inclusion criteria for this study, but they might have become an issue in the outcomes from this participant, as discussed in greater detail in the results and discussion chapters.

Participant CF was 21 years old and reported stuttering since age 4. He had received therapy at many points in his life for his stuttering, with the most recent being an intensive treatment program in 2009. He had never had a rhythmic speech-based therapy. His stuttering was rated as moderate by the experimenter and secondary speech-language pathologist, characterized by blocks and syllable or word repetitions, with visual concomitants including blinking and lip puckering. His speech in the 5 min of speech used to determine qualifications for this study displayed 6.36 %SS, 141.7 SPM, a naturalness rating of 5.83 for listeners, and a self-rated naturalness of 2.4.

All three participants reported normal hearing, normal or corrected vision, and no other speech, language, or neurological conditions. They were recruited through supervisors at the University of Georgia Speech and Hearing Clinic and through personal connections, using printed flyers previously approved by the University of Georgia’s Institutional Review Board (IRB). The study itself also had prior approval from the IRB, and all three participants gave their prior informed consent to participate using materials and methods approved by the IRB. Participants were paid $10 for each hour they spent participating in the study. The three participants who completed this study represent all three who began.
Materials

The experiment was conducted in two individual sessions for each participant. At the beginning of each session, the participant was seated in a comfortable chair in a quiet room and provided with a list of possible topic choices to use during monologues. Audiovisual recordings were made using a JVC Hard Disk Camcorder (MG130U) positioned 3 feet in front of the participant on a tripod. One computer was set up to deliver the rhythmic stimuli via Philips Rich Base In-Ear headphones. Stimuli were audio recordings of the tone patterns prescribed in each condition. A second computer was set up to allow the experimenter to access the Stuttering Measurement System (SMS; Ingham et al., 1999) software in order to collect data on stuttering frequency during the initial control condition and between condition monologues. The SMS is a freely available and commonly used software that allows a trained judge to gather percentage of syllables stuttered, syllables spoken per min, and perceived overall naturalness of speech. The program uses mouse-clicks to count each syllable in a speech sample, with left mouse-clicks representing non-stuttered syllables, and right mouse-clicks representing stuttered syllables. The SMS software converts the judge’s mouse-clicks of syllables spoken and stuttered into percentage of syllables stuttered (%SS) and syllables per min (SPM).

Dependent Variables

The measurement of a variable depends on its definition. There are numerous possible definitions of stuttering that could be used. For instance, Wingate’s (1964) behavioral definition of stuttering outlines specific behaviors such as repetitions and prolongations that are to be considered stutters. For the purposes of this study, the combination of Martin and Haroldson’s (1981) perceptual definition and an audiovisual stuttering judgment training program (Ingham et
al., 1999) was used. According to Martin and Haroldson’s definition, speech events are considered stuttered when they exceed a listener’s threshold for normal speech. As applied in this study, by trained judges, stuttering was judged as a perceptual phenomenon but with those judgments shaped by training intended to standardize some judgments of stuttered or nonstuttered speech.

As reviewed previously, definitions of naturalness can also vary. For this experiment, naturalness was judged as a general perception of how normal or acceptable the speech sounds. The 9-point rating scale developed by Martin et al. (1984) was used, with 1 representing highly natural sounding speech, and 9 representing highly unnatural sounding speech. Listeners may have based part of their ratings on such speech characteristics as rate, voice, fluency, volume, etc., but those parameters are not judged separately. Both stuttering frequency and speech naturalness variables were measured using the SMS software (Ingham et al., 1999).

**Procedure**

*Initial orientation and screening.* Individuals interested in participating in the study contacted the experimenter via e-mail. The experimenter gave those interested an overview of the study, including the time required to participate, tasks required, and possible compensation. Individuals who wished to participate were scheduled to begin study procedures.

Upon arriving for the first appointment, the experimenter reviewed the consent form with the participant and answered questions. Once consent had been obtained, the participant was asked to complete the Participant Information Form. After the experimenter reviewed the Participant Information Form and determined that the participant met the criteria for participation, the participant began the study procedures.
Establishing normal speech pattern (control condition). Five 1-min monologues were used to establish a baseline for each participant. The participant was given the following instructions:

You will be producing five 1-minute speech samples. During each sample, you will be speaking about a topic of your choice. When you hear the tone, please begin speaking. You can change topics if you like, but try to speak continuously for the entire minute. When you hear the second tone, stop speaking. At the end of each trial, you will be asked to rate how natural your speech sounded. You will make your rating on a scale from 1-9, with 1 being highly natural, and 9 being highly unnatural. Once you have made your rating, we will begin the next speech sample. Do you have any questions?

Experimental conditions. Each participant completed a total of 16 rhythmic stimulus conditions using combinations of four stimulus-on durations (0.1 s, 1.0 s, 2.0 s, 3.0 s) and four stimulus-off durations (0.25 s, 0.5 s, 1.0 s, 1.5 s). Table 1 shows each of the conditions as they are labeled throughout the presentation of the results, with the corresponding on- and off-time durations. Order of stimulus presentation was randomly assigned for each participant, with eight conditions being completed during the first session, and eight conditions being completed during a second session. For each condition, the participant produced five 1-min monologues on a topic or topics of his choice.

At the beginning of the experimental tasks, each participant was given the following instructions (adapted from Jones & Azrin, 1969):

You will hear a tone that goes on and off. The duration of the tone will sometimes be very brief and will sometimes be longer. The time between the tones will also vary. I want you to speak when you hear the tone and pause each time the tone goes off, then
Table 1. Experimental conditions used for this study, expressed as prescribed speaking time (the time that the stimulus was on, On-Time Duration, in seconds) and prescribed pause time (the time that the stimulus was off, Off-Time Duration, also in seconds).

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<th>Condition</th>
<th>On-Time Duration (S)</th>
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<td>A</td>
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<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>M</td>
<td>3</td>
<td>0.25</td>
</tr>
<tr>
<td>N</td>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>O</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>P</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>Q</td>
<td>Control</td>
<td>Control</td>
</tr>
</tbody>
</table>
begin speaking again when the next tone comes on. Do your best to stop and start immediately when the tone starts or stops, even if you need to break off or restart in the middle of a word. During very brief tones, you may have to divide long words between tones. Each trial will last for one minute. At the end of each trial, you will be asked to rate how natural your speech sounded. You will make your rating on a scale from 1-9, with 1 being highly natural, and 9 being highly unnatural. We will practice with each condition before beginning recordings.

Prior to beginning recordings for each condition, the stimulus was played aloud so that both the participant and experimenter could hear the tones. The participant was asked to practice speaking to the stimulus. Participants continued to practice with the stimulus until they could continue for 30 s judged by the experimenter to match the rhythmic pattern. If necessary, the experimenter modeled the correct speech pattern for the participant. Once the participant was able to correctly produce the speech pattern, recordings for that condition were started.

To control for carryover effects across conditions, the fifth trial in each condition was followed by at least one 2-min monologue, during which the participant was instructed to speak in his typical manner and with no rhythmic pattern. The experimenter used the SMS program to count stuttering frequency during these monologues. Each participant was required to produce speech that was rated to be within 10% of his baseline condition ratings for %SS. If that condition was not met with the first 2-min monologue, subsequent 2-min trials were continued until the participant’s speech returned to within 10% of baseline stuttering, or until five 2-min monologues had been completed.
Data Analysis

Defining and measuring dependent variables. Two research assistants trained in using the SMS software listened to and analyzed each of the speech samples in the study. Naturalness was not defined to the listeners, consistent with previous research (Ingham, Sato, Finn, & Belknap, 2001). Naturalness ratings were made at the end of each 1-min speech sample. For this study, only SPM, %SS, and naturalness ratings were collected. The pause control function, generally used when there are extended times of non-speech within a speaking sample, was not used in this experiment.

After completing the SMS training program (Ingham et al., 2007), both listeners judged each of the speech samples collected, and recorded the data for the three dependent variables into the Listener Record Form. The data from these forms was then transferred to a spreadsheet for further analysis. Data for naturalness ratings and stuttering frequency were collapsed by condition for each individual, and across individuals for group results.

Reliability. To insure intrarater reliability, the first listener independently re-rated 20% of the collected speech samples. To ensure that all experimental conditions were represented, the reliability data was based on the fifth 1-min speech sample for each condition, for each participant.

To insure interrater reliability, the ratings provided by each listener were compared trial by trial. If the ratings differed by more than 1 stutter per 100 syllables, or by more than 20%, for %SS, or by more than 2 scale points for naturalness ratings, the experimenter discussed the discrepancies with the listeners, and had them both re-rate the speech sample. The data used in the analyses were the averages of the two listeners’ ratings, or the averages of all ratings for speech samples that were re-rated for intra- or inter-rater reliability.
Fidelity. Two steps were taken to ensure that participants performed each of the experimental conditions accurately. Before video recordings of each condition were started, the participant demonstrated the condition for the experimenter, as detailed above. In addition, the fifth speech sample for each condition for each participant was analyzed using the computer software program Praat (Boersma & Weenink, 2011), a free and commonly used acoustical analysis software. The middle 30 s of each sample was divided into actual on- and off-time durations using visual and auditory analysis of the acoustical signal by a judge who was familiar with the prescribed on and off times for each sample. The beginning of an “on” segment was defined by the visual identification of an increase in intensity of the speech waveform, secondarily confirmed by the auditory speech sample. Similarly, the end of an “on” segment was identified by a prolonged decrease in the intensity of the speech waveform, confirmed by an absence of phonation, frication, or other speech-related sound in the speech sample. For instances where the judge expected speech to be present but the intensity of the waveform did not indicate speech, the judge relied on the auditory speech sample to indicate the presence of a stuttering “block”, which would still be considered part of the “on” segment. These data became important to the interpretation of this study’s findings and are discussed as results in Chapter Three.

Reliability of fidelity data. Twenty-five percent of the samples analyzed using Praat were re-analyzed to insure reliability of the analysis. Only the original data was used in other analyses.
CHAPTER 3

RESULTS

This chapter presents results for actual on- and off-time durations, stuttering frequency, observer-judged speech naturalness, and self-rated speech naturalness. For each variable, individual results for each participant are presented, followed by results for the group as a whole. All data are presented descriptively because of the very small number of participants, and to allow examination of the differing patterns of results that occurred across speakers.

On- and Off-time Durations

The participants in this experiment were assigned 16 experimental conditions, with varying on- and off-time durations. Therefore, the first relevant results that should be presented are those regarding each participant’s ability to complete the prescribed conditions.

Participant AJ. As seen in Figure 1, Participant AJ was inconsistent in his ability to correctly perform the experimental conditions. His shortest mean on-time duration was 0.30 s, achieved when the prescribed condition included an on-time duration of 0.1 s. AJ most accurately completed conditions for which the prescribed on time was 1.0 s. In regard to off-time durations, AJ showed the most difficulty with the shortest off-time duration, 0.25 s, with the exception of condition A, where his actual off-time durations had a mean of 0.14 s. Overall, AJ might be described as completing the 1.0-s on-time duration conditions accurately, but he was inaccurate in completing the 2.0-s and 3.0-s on-time duration conditions accurately, because of
Figure 1. Prescribed and actual duration data for Participant AJ.
inconsistent errors in on times, and because he consistently shortened the off-time durations.

Participant BW. As seen in Figure 2, Participant BW had, in many ways, actual speech durations similar to those of AJ. His shortest on-time duration was 0.29 s for the prescribed 0.1-s on-time duration. He was the least consistent in off-time duration during the 2.0-s on-time duration conditions. His ability to correctly produce the stimulus pattern for the 3.0-s on-time duration conditions improved as the off-time duration increased. Overall, BW does not show any clear pattern in under- or overestimating on- and off-time durations.

Participant CF. Figure 3 shows that Participant CF had actual speech durations for the shortest on-time stimuli that were similar to those of the other two participants. His shortest actual off-time duration was 0.29 s. Similar to Participant AJ, CF seemed to have the most difficulty with the 0.25-s off-time duration conditions. However, in contrast to the other participants, CF’s actual on-time durations for the 2.0-s and 3.0-s on-time stimuli were consistently shorter than prescribed, regardless of prescribed off-time duration. He also showed difficulty with the 0.5-s off-time duration stimuli with both the 2.0-s and 3.0-s on-time durations. The relatively short on times may have caused him to also have longer than prescribed off-time durations on these stimuli. Overall, CF was the least accurate of the participants in producing the prescribed off-time duration.

Accuracy of on-time and off-time durations across participants. Overall, it can be seen that the participants showed great variability in their ability to correctly perform the experimental conditions. While some overall trends in performance can be identified, there does not seem to be a specific stimulus condition that all participants are able to accurately follow.
Figure 2. Prescribed and actual duration data for Participant BW.

Figure 3. Prescribed and actual duration data for Participant CF.
All three of these participants were unable to successfully produce speech with the prescribed on-time duration of 0.1 s. With the longer prescribed on-time durations, participants usually had longer than prescribed off-time durations. However, with the prescribed on-time duration of 0.1 s, participants all had shorter than prescribed off-time durations. This is most likely due to participants attempting to keep up with the stimulus, but being unable to produce speech segments measuring 0.1 s.

Another trend that can be seen within this data is that participants had difficulty pausing for only 0.25 s, with the exception of during the condition that combined a 0.25-s off time with a 0.1-s on-time.

*Reliability of duration data.* Twenty percent of the data analyzed to determine actual on- and off-durations for each of the stimuli were re-analyzed by the experimenter for intrarater reliability. Figure 4 shows the results for these analyses. Second ratings of off-time durations fell within 12% of the original rating for each of the samples. Second ratings of the on-time durations fell within 15% of the original rating for each of the samples.

*Stuttering Frequency*

*Participant AJ.* AJ’s baseline stuttering frequency was 24.83%SS. Figure 5 shows stuttering frequencies for AJ across all experimental conditions, with actual on- and off-time durations. For conditions with stimulus-on time of 0.1 s, stuttering frequency ranged from 0 to 0.34%SS.
Figure 4. Intrarater reliability of duration data.

Figure 5. Percent syllables stuttered (%SS) for Participant AJ, shown with actual on-time and off-time durations (in s).
Stuttering increased slightly with a stimulus on-time duration of 1 s, with the highest frequency being 2.12%SS. Stuttering frequency continued to increase for the longer stimulus on-time durations, averaging 5.14%SS for stimulus on-time durations of 2-3 s. Overall, AJ showed less stuttering during the two shorter on-time durations, as compared with the longer on-time durations.

Participant BW. BW’s baseline stuttering frequency was 2.18%SS. Figure 6 shows stuttering frequency across all stuttering conditions, as well as on and off durations. Stuttering frequency remained below 1%SS for all experimental conditions, ranging from 0 to 0.87%SS. Overall, BW produced very little stuttering during all rhythmic stimulus conditions.

Participant CF. CF’s baseline stuttering frequency was 6.36%SS. Figure 7 shows stuttering frequency across all stuttering conditions, as well as on and off durations. He showed the most variability with conditions for which the stimulus on-time duration was 0.1 s. For the two shorter off-time durations, stuttering frequency was at or below 0.57%SS. However, with the two longer off-time durations, his stuttering frequency rose to 9.49 and 2.49% SS. This may be due in part to the longer pause durations influencing the actual syllables per min for these conditions. Stuttering frequency for CF varied considerably throughout the remaining experimental conditions, without any clear patterns.

Group. Figure 8 shows the group’s mean stuttering frequency for each of the experimental conditions. A trend of increased stuttering frequency can be seen as on-time duration increases. There does not appear to be a trend in relation to prescribed off-time duration.
Figure 6. Percent syllables stuttered (%SS) for Participant BW, shown with actual on-time and off-time durations (in s).

Figure 7. Percent syllables stuttered (%SS) for Participant CF, shown with actual on-time and off-time durations (in s).
Figure 8. Mean percent syllables stuttered (%SS) for all three participants, shown with mean actual on-time and off-time durations (in s).
Naturalness

**Participant AJ.** Figure 9 shows both self-rated and listener-rated naturalness for all conditions. AJ had the most severe stuttering of participants within the study. His speech naturalness for his baseline speech was judged to be 8.25 by listeners and 7.4 by himself, or very unnatural sounding. Of the experimental conditions, those with a stimulus on-time duration of 0.1 s were judged to be the most unnatural sounding, both by the participant and by the listeners. For the other conditions, listeners judged that his speech was fairly consistent in regard to naturalness, with the exception of the last condition, which was judged as highly unnatural sounding. More often than not, the participant rated himself as sounding more natural than did the listeners. Across all conditions, AJ’s self-judged naturalness differed from listener naturalness ratings by a mean of 1.61 scale points. A trend related to stimulus off-time duration is also evident in his ratings; he judged those with longer off-time durations as sounding more unnatural than the same on-time durations with shorter pauses.

**Participant BW.** Figure 10 shows both self-rated and listener-rated naturalness for all conditions. For the baseline condition, BW rated himself as sounding somewhat unnatural, while the listeners judged his speech to sound quite natural. Unlike AJ, BW often rated himself as sounding less natural than did listeners, with the exception of the conditions with the shortest on-time durations. With each of the four on-time durations, BW rated himself as sounding the least natural when the off-time duration was 1.5 s. Listener ratings showed the same trend. Overall, listeners judged the speech of BW to sound the most natural during conditions with a longer stimulus on-time duration and a shorter stimulus off-time duration. Self-rated naturalness and listener naturalness ratings differed by a mean of 1.91 scale points.
Figure 9. Naturalness ratings for Participant AJ.

Figure 10. Naturalness ratings for Participant BW.
Participant CF. Figure 11 shows both self-rated and listener-rated naturalness for all conditions. Out of the three participants, self-rated naturalness scores and listener naturalness ratings differed the most for participant CF. On average, self-rated naturalness and listener naturalness ratings differed by 4.08 scale points. For each condition, the participant judged himself as sounding much more natural than did the listeners. Overall, ratings of naturalness given by the listeners ranged from 5.8 to 6.9, indicating somewhat unnatural sounding speech. Conditions with the shortest on-time duration, however, were rated between 7.7 and 8.2, indicating very unnatural sounding speech. In contrast, CF rated the shortest on-time conditions as sounding the most natural.

Group. Figure 12 shows the mean self-rated naturalness and mean listener naturalness ratings for each condition. For all conditions, self-rated naturalness scores were less than those of listener naturalness ratings, a trend that was unduly influenced in this small group by the consistently lower ratings of participant CF. Both listeners and participants judged the conditions with a stimulus on-time duration of 0.1 s to be the most unnatural sounding. Conditions with the longest off-time duration were also rated as sounding the most unnatural when compared to other conditions with the same on-time duration but shorter pause times.

Relationships Between Variables

Participant AJ. The correlation matrix (Pearson product-moment correlation coefficients, $r$) presented in Table 2 shows that the strongest correlation for AJ, $r = -0.820$, was between on-time and self-rated naturalness, meaning that as on-time increased, naturalness ratings decreased or his speech sounded more natural. A correlation of 0.799 was found between
Figure 11. Naturalness ratings for Participant CF.

Figure 12. Mean naturalness ratings for all three participants.
Table 2. Pearson product-moment correlations ($r$) between variables for Participant AJ.

<table>
<thead>
<tr>
<th>AJ</th>
<th>Actual On Time</th>
<th>Actual Off Time</th>
<th>%SS</th>
<th>Listener Naturalness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Off Time</td>
<td>0.378</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>%SS</td>
<td>0.799</td>
<td>0.408</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Listener Naturalness</td>
<td>-0.673</td>
<td>-0.353</td>
<td>0.177</td>
<td>-</td>
</tr>
<tr>
<td>Self-Rated Naturalness</td>
<td>-0.820</td>
<td>-0.154</td>
<td>-0.109</td>
<td>0.809</td>
</tr>
</tbody>
</table>
on-time and %SS, showing that stuttering frequency increased as on-time increased. Listener naturalness ratings and self-rated naturalness were also highly correlated, at $r = 0.809$, showing similar variations across conditions in how the participant and the judges rated his naturalness.

**Participant BW.** Analysis of speech data for BW showed a strong (as defined by Choudhury, 2009) negative correlation ($r = -0.658$) between actual on-time and self-rated naturalness (Table 3). A strong negative correlation ($r = -0.787$) was also seen between actual on-time duration and listener rated naturalness. A correlation of 0.681 was found between naturalness ratings of the listeners and the participant.

**Participant CF.** The correlation matrix presented in Table 4 shows the relationships between variables for CF. The strongest correlation for this participant was found between actual on-time duration and listener naturalness ratings ($r = -0.882$). However, in contrast to the other participants, a positive correlation of 0.703 was found between actual on-time duration and self-rated naturalness, showing that as actual on-time duration increased, naturalness ratings also increased, indicating speech that was judged to be less natural sounding. This may be due, in part, to an increase in stuttering frequency.

**Group.** Finally, Table 5 shows that the highest correlation found for the group as a whole was between actual on-time duration and self-rated naturalness ($r = -0.503$). A correlation of 0.199 was found between self-rated naturalness and listener naturalness ratings, suggesting a very weak relationship for the three participants combined. Again, however, the overall weak relationship is most likely due to the negative relationship found with CF, because the other two participants showed positive correlations.
Table 3. Pearson product-moment correlations ($r$) between variables for Participant BW.

<table>
<thead>
<tr>
<th></th>
<th>Actual On</th>
<th>Actual Off</th>
<th>%SS</th>
<th>Listener Naturalness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Off Time</td>
<td>0.595</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>%SS</td>
<td>0.173</td>
<td>0.103</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Listener Naturalness</td>
<td>-0.787</td>
<td>-0.348</td>
<td>-0.18</td>
<td>-</td>
</tr>
<tr>
<td>Self-Rated Naturalness</td>
<td>-0.658</td>
<td>-0.141</td>
<td>-0.279</td>
<td>0.681</td>
</tr>
</tbody>
</table>

Table 4. Pearson product-moment correlations ($r$) between variables for Participant CF.

<table>
<thead>
<tr>
<th></th>
<th>Actual On</th>
<th>Actual Off</th>
<th>%SS</th>
<th>Listener Naturalness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Off Time</td>
<td>0.687</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>%SS</td>
<td>0.337</td>
<td>0.263</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Listener Naturalness</td>
<td>-0.882</td>
<td>-0.56</td>
<td>-0.451</td>
<td>-</td>
</tr>
<tr>
<td>Self-Rated Naturalness</td>
<td>0.703</td>
<td>0.36</td>
<td>0.696</td>
<td>-0.69</td>
</tr>
</tbody>
</table>

Table 5. Pearson product-moment correlations ($r$) between variables for the three participants combined.

<table>
<thead>
<tr>
<th></th>
<th>Actual On</th>
<th>Actual Off</th>
<th>%SS</th>
<th>Listener Naturalness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Off Time</td>
<td>0.776</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>%SS</td>
<td>0.348</td>
<td>0.300</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Listener Naturalness</td>
<td>-0.489</td>
<td>-.0314</td>
<td>0.305</td>
<td>-</td>
</tr>
<tr>
<td>Self-Rated Naturalness</td>
<td>-0.503</td>
<td>-0.448</td>
<td>-0.250</td>
<td>0.199</td>
</tr>
</tbody>
</table>
Prior Predictions

This study was guided by the five specific hypotheses presented at the end of Chapter One. Because of the small number of participants, and because of the data structure obtained (unequal numbers of trials with the relevant stimulus-on or stimulus-off durations, and positively skewed distributions), the decision was made to address these hypotheses descriptively, rather than through the use of inferential or even nonparametric statistics. Thus, each hypothesis was addressed in two ways: first, whether the mean data supported or did not support that hypothesis, and then second, whether the raw data as distributions showed overlaps or a clear demarcation between the two sets of data points.

Hypothesis 1 predicted that stimulus-on durations of greater than 1 s would result in more stuttering than stimulus-on durations of 1 s or less, regardless of stimulus-off duration. For mean data from each individual participant, as well as the group as a whole, this hypothesis was supported. Examination of the data from individual 1-min trials, however, shows considerable overlap in stuttering frequencies for the short and long on-time durations, with only two of the stuttering frequencies from the longer duration stimuli falling above the highest stuttering frequency for the shorter duration stimuli (Figure 13). For individual participants, AJ had the least amount of overlap in stuttering frequency between the short and long duration stimuli, with only one of the longer duration stuttering frequencies falling within the shorter duration range. Participants CF and BW had nearly all of the stuttering frequencies for the longer duration stimuli fall within the range of those produced during shorter duration stimuli.
Figure 13. Stuttering frequencies of conditions with on-time durations of < 1 s and conditions with on-time durations of > 1 s.
Hypothesis 2 predicted that stimulus-on durations of greater than 1 s would result in more natural sounding speech than stimulus-on durations of 1 s or less, regardless of stimulus-off duration. For the group as a whole, this hypothesis was also supported by mean data for both listener-rated and self-rated speech naturalness. However, as with the results regarding hypothesis 1, over half of the ratings for individual 1-min trials with longer stimuli fell within the range of the shorter duration stimuli ratings (Figures 14 and 15). Listener rated naturalness for AJ followed the pattern for the group as a whole. However, there was much less overlap between the two groups for self-rated naturalness. AJ rated all of the trials associated with longer duration stimuli as sounding more natural with the exception of two, both of which had an off-time duration of 1.5 s. For BW, there was a clear difference between the listener-rated naturalness for trials completed with the longer and shorter duration stimuli; only one rating from longer-stimulus conditions fell within the range of the shorter stimuli, and a difference of 5.12 scale points was found for the average of the longer duration stimuli compared to the shorter duration trials. There was much less of a difference between naturalness ratings for self-rated naturalness. CF showed a clear difference in speech naturalness, with no ratings from the longer duration group falling within the range of the shorter duration group. Also, CF was the only participant for whom self-rated naturalness of the shorter duration stimuli was judged to be more natural sounding than the stimuli in the longer duration group.
Figure 14. Listener naturalness ratings of conditions with on-time durations of < 1 s and conditions with on-time durations of > 1 s.

Figure 15. Self-rated naturalness of conditions with on-time durations of < 1 s and conditions with on-time durations of > 1 s.
Hypothesis 3 predicted that stimulus-off durations of less than 1 s would result in more natural sounding speech than stimulus-off durations of 1 s or more, regardless of stimulus-on duration. For the group mean data, this hypothesis was supported for self-rated naturalness but not supported for listener-rated speech naturalness (Figures 16 and 17). However, all ratings are so similar that the better supported conclusion is that no meaningful difference in speech naturalness can be seen between the short off-time duration stimuli and the longer off-time duration stimuli. For individual participants CF and AJ, the hypothesis was also supported for self-rated naturalness but not for listener-rated naturalness. BW was the only participant for whom the hypothesis was found to be supported for both self-rated and listener-rated naturalness. As was also the case for the group data, however, the differences between the longer and shorter off-time duration groups are small.

Hypothesis 4 predicted that stimulus-off durations of less than 1 s would result in less stuttering than stimulus-off durations of 1 s or more, regardless of stimulus-on duration. This hypothesis was not supported for the group as a whole or for any participant individually (Figure 18). However, similar to the results for hypothesis 3, there is very little difference between the stuttering frequencies for the longer or shorter duration off-time stimuli. The one exception occurred for participant AJ, who showed a stuttering frequency of 5.63% SS for the shorter off-time duration stimuli, and 4.13% SS for the longer duration off-time stimuli.

Hypothesis 5 predicted that stimulus-on durations of more than 1 s combined with stimulus-off durations of less than 1 s would produce the most natural sounding speech. This hypothesis was supported both for the group as a whole and for participants AJ and BW (Figures 19 and 20). For CF, the hypothesis was supported for listener-rated speech naturalness but
Figure 16. Listener naturalness ratings of conditions with off-time durations of < 1 s and conditions with off-time durations of > 1 s.

Figure 17. Self-rated naturalness of conditions with off-time durations of < 1 s and conditions with off-time durations of > 1 s.
Figure 18. Stuttering frequency of conditions with off-time durations of < 1 s and conditions with off-time durations of > 1 s.

Figure 19. Listener-rated naturalness for conditions combining a short off-time duration with a long off-time duration, and conditions that do not meet those qualifications.
Figure 20. Self-rated naturalness for conditions combining a short off-time duration with a long off-time duration, and conditions that do not meet those qualifications.
not for self-rated speech naturalness. Similar patterns of overlap in range are present from hypothesis 2 regarding on-time duration and speech naturalness. For this hypothesis, however, there is also more overlap seen for participant BW.

Reliability of speech data. Intrarater reliability for the primary listener in this study is very high. With regard to naturalness ratings, the listener was within 1 scale point for each of the speech samples that were re-rated. Appendix E shows the intrarater reliability data for each of the three participants.
CHAPTER 4
DISCUSSION

Summary of Results

The three participants in this study all varied considerably both in their baseline speech patterns and in their response to the rhythmic stimulus conditions introduced during the study.

On-time and off-time durations. This study was based on varying on- and off-time durations for rhythmic stimuli to determine the effect on stuttering and speech naturalness. For the purpose of this study, the experimenter chose to define rhythm as a recurrent pattern of on- and off-time durations. The first question that arose when analyzing the data for the study was whether or not the participants could successfully complete the prescribed conditions. Participants were required to demonstrate to the experimenter that they could successfully produce speech in time with the rhythmic stimulus, with the stimulus being audible to both the participant and experimenter. It also sounded to the experimenter during the speech trials as if participants were speaking in time with the rhythmic stimuli. From acoustic analysis data collected later, however, it is clear that participants had difficulty maintaining speech patterns that satisfied the strict parameters of the stimuli. In particular, the most difficult on-time duration was 0.1 s; all participants were unable to produce speech of this short duration. Participants also struggled to maintain stimulus-off or pause durations that were as long as prescribed. However, there were no consistent patterns among the participants as to which stimuli combinations gave them the most difficulty, with the exception of the shortest on-time duration stimuli.
Stuttering frequency. An upward trend can be seen in the stuttering frequency for the group as on-time duration of the stimuli increased. However, each participant had a unique pattern in stuttering frequency. AJ’s stuttering increased with increased speaking time, similar to the group. BW maintained a low rate of stuttering, regardless of on-time duration. One possible explanation for this pattern of results might have been if BW also used a reduced speech rate throughout all conditions. Speech rate data show that BW does not appear to be speaking at a different rate of speech from the other participants, however, and his speech rate (as syllables per min, SPM) varied across the different conditions. It can then be concluded that speaking rate did not account for BW’s relatively low stuttering frequency as compared to the other participants.

The final participant, CF, was unable to maintain fluency even at the shortest on-time duration. One possible explanation for this is that his lower SPM during the longer off-duration stimuli inflated the percentage of syllables stuttered. The raw data for CF, though, shows that he did have more actual moments of stuttering during these shortest duration stimuli than did the other participants.

Naturalness. Similar to the stuttering frequency results, data regarding speech naturalness varied considerably by participant. Overall, the shortest stimulus on-time duration was considered to sound the most unnatural, especially when it was combined with the longest off-time duration. Longer off-time durations were also perceived to be the most unnatural, both by listeners and the participants.

Relationships between variables. The most significant relationship between variables for the group as a whole was found between self-rated speech naturalness and on-time duration. Individual participant data tended to show stronger correlations between on-time duration and naturalness.
Hypotheses of this study. The group mean data seemed to support the first hypothesis, that on-time durations of greater than 1 s would produce more stuttering than on-time durations of less than 1 s (4.09 vs. 1.14%SS). Because of the substantial overlap between the two groups, however, both for the group as a whole and for 2 of the 3 participants, the better-supported conclusion is that there was no meaningful difference in stuttering frequency during shorter versus longer on-time durations. Only BW showed a clear difference in stuttering frequency between the shorter and longer on-time durations, when that division was drawn at the 1.0-s duration.

Results for speech naturalness, while also overall supporting hypothesis 2, also follow the pattern of having considerable overlap. There are also more individual differences amongst participants with naturalness ratings. Participant AJ had the most overlap in naturalness ratings between longer and shorter duration stimuli, while BW had almost no overlap at all in ratings of his speech.

Hypothesis 3 predicted that stimulus-off durations of less than 1 s would result in more natural sounding speech than stimulus-off durations of 1 s or more, regardless of stimulus-on duration. This hypothesis was not supported; the means were similar and there is clear overlap between the distributions. Similarly, Hypothesis 4, which stated that stimulus off-time durations of less than 1 s would result in less stuttering than stimulus off-time durations of greater than 1 s, was not supported by the results of the group as a whole, or of any individual participants. Overall, the variations in off-time duration introduced during this study did not appear to influence stuttering frequency or speech naturalness for these speakers.

The prediction that stimulus-on durations of more than 1 s combined with stimulus-off durations of less than 1 s would produce the most natural sounding speech was supported by the
results of the group and for 2 of the individual participants. For CF, the hypothesis was supported only by listener-rated speech naturalness. However, it should also be noted here that there was significant overlap between the two groups, similar to the results seen for Hypothesis 2.

Comparison to Previous Research

On-time and off-time durations. The stimulus-on time duration of 0.1 s used for this study was selected based on previous studies by Jones and Azrin (1969) and Finn and Ingham (1994). However, one aspect missing from both of these previous research reports is data regarding the accuracy of participants’ ability to perform the specified rhythmic speech conditions. Jones and Azrin (1969), when reviewing the results of their study, state that participants paused “at least briefly during each stimulus-off period” (p. 226). Finn and Ingham (1994), to measure the accuracy with which the participants were following the rhythmic stimulus, used on-line ratings as well as an off-line perceptual matching task. On-line judgments of the accuracy with which participants produced the correct stimulus pattern were, in the current study, shown to be unreliable when compared to acoustical analysis of speech samples. Given the lack of reliability data for timing of the speech samples in previous publications, one is unable to determine whether each pause was actually 1 s, as prescribed, or perhaps closer to 0.5 s. The current study, with precise data regarding actual on- and off-time durations for each participant, is able to more clearly define speech samples as either containing shorter or longer speech and pause durations. These data may be useful in providing a better understanding of when stuttering is most likely to return, as well as which durations result in the most natural sounding speech.
Stuttering frequency. In general, this study further supports the use of a rhythmic stimulus to reduce stuttering. As previously discussed, the studies by Jones and Azrin (1969) and Finn and Ingham (1994) both showed that rhythmic stimuli with on-time durations of about 1 s or less successfully reduced stuttering. Overall, similar results can be seen with the current study. However, this study also shows a large amount of variability across participants. For instance, participant BW maintained a stuttering frequency of less than 1%SS on all experimental conditions, which included stimulus on-time durations of up to 3 s. In contrast, participant CF was unable to produce speech with a low frequency of stuttering even during conditions with the shortest on-time duration of 0.1 s. This experimenter questions why CF was not able to produce stutter-free speech with the 0.1 s on-time duration, which is basically a rhythmic beat that has been shown in numerous previous studies to be one of the most successful fluency inducing conditions. A possible answer was provided by the speaker himself, who commented during one of these trials that the pattern reminded him of a speech pattern he had learned to use during a previous treatment. In essence, it could have been that his attempts to use those techniques and to maintain the rhythm were too complex and resulted in stuttering. The other possibility is that CF simply represents that minority of speakers who do not respond as well to rhythmic speech patterns as do most speakers. In the study by Andrews et al. (1982), one of the three participants, while showing some reduction in stuttering, did not completely respond to syllable timed speech.

Naturalness. One purpose of this study was to investigate the perceived naturalness of speech resulting from varying rhythmic speech conditions. As expected based on previous research, conditions with the shortest on-time duration, specifically 0.1 s, were judged by both the speaker and listeners to be very unnatural sounding. It is difficult to draw accurate
comparisons to previous research, however, which shows that naturalness decreases as stimulus
time increases due to a return of stuttering, given that each of the 3 participants had such varying
patterns of stuttering frequency. The relatively poor naturalness ratings obtained in the present
study for off-times longer than 1.0 s were also consistent with previous reports that pause times
longer than 0.5-1.0 s are perceived as unnatural (Logan et al., 2002).

Reliability data from this study support the clinical and experimental use of the speech
naturalness rating scale developed by Martin et al. in 1984. Given that speech naturalness is
such an important aspect of any stuttering therapy, it is vital to have a tool that can accurately
and consistently reflect resulting speech.

Limitations of the Current Study and Future Research

The main limitation of this study was the small number of participants involved. This
became even more of an issue because each of the participants showed such differences in
frequency of stuttering and speech naturalness ratings. One participant in particular, CF, showed
a pattern of stuttering that appears to be relatively unusual, given previous research on the effects
of a rhythmic beat. It might be reasonable to include only speakers who meet some initial
criterion for reducing their stuttering in a study such as this one that is intended to explore
degrees or levels of reduction. The obvious problem there, of course, is that excluding speakers
who do not reduce their stuttering leads to findings with limited applicability. BW may have
shown lower rates of stuttering throughout all experimental conditions due to his low baseline
stuttering frequency.

A second question that comes to mind is at what point the rate of the rhythmic stimulus
affects its ability to reduce stuttering. Given that this was the case with only 1 of the 3
participants, it seems more likely that the rate of a traditional rhythmic stimulus, or in the case of this study, stimulus-off time duration, does not have an effect on stuttering frequency. Repeating the study with a larger sample size could help better delineate differences that were unclear in the present study due to its limited sample size.

Another limitation of the study was that some of the stuttering frequencies reported may not have been accurate reflections of stuttering frequency due to the process by which the speech was analyzed. In this study, each speech sample was 60 s in duration. Longer pause durations decreased the amount of speech analyzed within each sample, when compared to the same on-time duration with a shorter off-time duration. This often resulted in far fewer syllables being produced in a speech sample. Given that stuttering frequency in this study was measured as a percentage of syllables stuttered, longer pause durations may have unduly inflated the resulting stuttering frequency. Future research may include analyzing data not only by the percentage of syllables stuttered, but also by another method which would better manage the effect of the increased pause durations. Analysis of SPM and stutterfree SPM may also be helpful in clarifying the influence of the varying on- and off-time durations.

Data analysis in this study only considered a small portion of the actual on- and off-time durations of each participant, under the assumption that participants produced similar speech patterns during each trial within a condition and throughout each trial. It was also assumed that ratings of stuttering frequency would be similar for each trial within a condition. Analysis of each speech sample individually may have revealed that participants were not consistent within or between trials. Exploration of each sample individually for relationships between on- and off-time durations, stuttering frequency and naturalness may have yielded different results for some participants.
Treatment Implications

Bothe, Finn, and Bramlett (2007) discussed the general idea that research regarding treatments should not be deemed successful only if they help every individual with the targeted disorder, but that any research that may be able to help some subset of a population is needed and worthwhile. While this study does not by any means highlight a treatment strategy that would become a benchmark in stuttering therapy, the information gained has led to a better understanding of the influence of rhythm on stuttering frequency and speech naturalness. It may also be used to develop research to investigate other possible rhythmic treatments for stuttering.
REFERENCES


APPENDIX A

INFORMED CONSENT

The Impact on Stuttering Frequency and Speech Naturalness of Different Stimulus-on and Stimulus-off Durations During Rhythmic Stimulation

Consent Form

I, __________________________________________________, agree to take part in a research study entitled “The Impact of Different Stimulus-on and Stimulus-off Durations During Rhythmic Stimulation of Stuttering Frequency and Speech Naturalness”, which is being conducted by Robin Selman (phone 972 523-9335) in the Department of Communication Sciences and Special Education at the University of Georgia, under the direction of Dr. Anne Bothe, University of Georgia (phone 706 542-0436). My participation is voluntary; I can refuse to participate or stop taking part at any time without giving any reason, and without penalty or loss of benefits to which I am otherwise entitled. I can ask to have information related to me returned to me, removed from research records, or destroyed.

The purpose of this study is to examine the effects of different “stimulus-on” (that is, talking) and “stimulus-off” (that is, pausing) times on the speech of persons who stutter. It has been well established that rhythmic speech reduces stuttering in people who stutter. However, rhythmic stimulation has rarely been used as a treatment for stuttering, because it often results in very unnatural sounding speech. It is the goal of the experimenters to highlight which changes in rhythmic stimulus, if any, allow persons who stutter to produce speech that is both fluent and more natural sounding than traditional rhythmic speech. This may lead to the development of a new treatment approach for adults who stutter.

The benefits that I may expect from this study are to learn more about stuttering in general and my own stuttering in particular. I will also be given information about access future treatment for my stuttering, if I desire it. I understand that this study will not provide treatment for my stuttering.

If I volunteer to take part in this study, I will be asked to do the following things:

1) Provide information regarding my history of stuttering, include age of onset and any treatment I have received.

2) Have myself video recorded while speaking under 16 different rhythmic conditions. Each condition will require me to try to time my speech to a series of beeps while I am talking for 1 minute. For example, I might be asked to talk in a rhythmic pattern that is 0.5 seconds of “on time” followed by 1.0 second of “off time.” The experimenter will give me specific instructions and an opportunity to practice before each condition.

3) Provide ratings regarding the amount of effort put forth on speaking tasks.
4) My participation in this study will consist of 2 sessions on 2 separate days. Each session will last approximately 2 hours. I may take breaks between conditions whenever I need to.

There are no reasonably foreseeable risks to participants from participating in this study, with the possible exception of embarrassment if video recordings of their speech were to be seen by unauthorized persons. I understand that the researcher will be videotaping my speech during this study and that other research assistants will see those videotapes for the purposes of counting how much I stutter and rating the overall “naturalness” of the different rhythmic speaking conditions. I understand that the videotapes will be kept in the Stuttering Laboratory at the University of Georgia until this study is completed and will then be destroyed. All individually-identifiable information will be kept confidential. I understand that the videotapes will be kept as secure as possible, in a locked room, and the researchers will do everything reasonably possible to ensure that no unauthorized persons see them. I understand that all other records of my participation will be labeled only with my code number, with the exception of this consent form and the one intake information form that will remain with this form.

I will receive $25 for each session that I complete, up to $50 for completion of the entire study.

The researcher will answer any further questions about the research, now or during the course of the project, and can be reached by telephone at: 972-523-9335.

My signature below indicates that the researchers have answered all of my questions to my satisfaction and that I consent to volunteer in this study. I have been given a copy of this form.

________________________  __________________________
Robin Selman                        Signature                    Date
972-523-9335  rselman@uga.edu

________________________  __________________________
Name of Participant                Signature                    Date

Please sign both copies, keep one and give one to the researcher

Additional questions or problems regarding your rights as a research participant should be addressed to The Chairperson, Institutional Review Board, University of Georgia, 629 Boyd Graduate Studies Research Center, Athens, Georgia 30602-7411; Telephone (706) 542-3199; E-Mail Address IRB@uga.edu
APPENDIX B

PARTICIPANT INFORMATION FORM

The Impact of Different Stimulus-on and Stimulus-off Durations During Rhythmic Stimulation of Stuttering Frequency and Speech Naturalness

Participant Information Form

Name:_____________________________________________________
Date of Birth:_____________________________________________
ID Number:_______________________________________________

Consent Signed:__________________________________________

Hearing or Vision Problems:_______________________________

Primary Language:________________________________________

Age of Onset of stuttering:_______________________________

Previous Treatment for stuttering:
_________________________________________________________
_________________________________________________________

Other Neurological Disorders:________________________________

Other Speech or Language Disorders:___________________________


APPENDIX C

INITIAL CONTACT- ELIGIBILITY SCREENING

Phone [or email] script for initial contact – Eligibility screening

The Impact of Different Stimulus-on and Stimulus-off Durations During Rhythmic Stimulation of Stuttering Frequency and Speech Naturalness

Thank you for your interest study regarding stuttering. Before we can continue, I would like to establish that you meet the guidelines for participation in this study. We are looking for people for whom all of the following statements are true. Please listen to [or read] the entire list, and then tell me if all of them are true for you. If any one or more of these statements are not true for you, you do not need to tell me which ones. Just say “At least one of those is not true for me.” After you have heard [read] the whole list, you may also say that you have decided not to participate in the study after all but without answering the question or giving me any information about yourself.

We need people for whom all of the following are true.

1. I have been stuttering at least some of the time since childhood.
2. I can hear well enough to listen to videotapes, and I would agree to have my hearing screened as part of the study.
3. I do not have any other speech or language disorders.
4. I do not have any neurological disorders.

Are all of those statements true for you? Remember that you can also tell me that you have decided not to participate in the study, instead of answering this question.

[If the answer is “yes, all are true for me”]
Thank you. We would like to schedule you to come for the first session of the study. We will give you more information about the study at that time.

[If the answer is “no, at least one is not true for me”]
Thank you. We need people for whom all of these are true, but we appreciate your trying to volunteer. Can I provide you with any further information about stuttering or speech-language pathology resources in the area?

[if the answer is “I would rather not participate after all”]
Thank you. We appreciate your trying to volunteer. Can I provide you with any further information about stuttering or speech-language pathology resources in the area?
NEEDED:
Volunteers who Stutter

I am looking for volunteers who stutter to help me complete my Master’s thesis project. If you are between the ages of 18-60 and have been stuttering since childhood, you may qualify. Participation includes an interview and speaking tasks. Compensation may be provided.

If you are interested in participating or would like further information, contact:
Robin Selman
UGA Graduate Student-Speech Language Pathology

stutter@uga.edu
972-523-9335
APPENDIX E

INTRARELIABILITY DATA FOR PRIMARY LISTENER

Figure 13. First and second ratings of stuttering frequency for Participant AJ.

Figure 14. First and second naturalness ratings for Participant AJ.
Figure 15. First and second rating of stuttering frequency for Participant BW.

Figure 16. First and second naturalness ratings for Participant BW.
Figure 17. First and second ratings of stuttering frequency for Participant CF.

Figure 18. First and second naturalness ratings for Participant CF.
APPENDIX F

INTRARATER RELIABILITY OF DURATION DATA

Figure 19. Intrarater reliability of duration data sorted by prescribed on-time duration.

Figure 20. Intrarater reliability of duration data sorted by prescribed off-time duration.