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The effect of SpeechEasy on stuttering frequency in laboratory conditions

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Abstract

The effect of SpeechEasy on stuttering frequency during speech produced in a laboratory setting was examined. Thirteen adults who stutter participated. Stuttering frequencies in two baseline conditions were compared to stuttering frequencies with the device fitted according to the manufacturer's protocol. The fitting protocol includes instructions for deliberate use of vowel prolongation. Relative to the initial baseline condition, stuttering was reduced by 74%, 36%, and 49% for reading, monologue, and conversation, respectively. In comparison, stuttering was reduced by 42%, 30%, and 36%, respectively with the device in place, but before participants were instructed to deliberately prolong vowels. Examination of individual response profiles revealed that although stuttering reduced in the device compared to the baseline conditions during at least one of three speech tasks for most participants, degree and pattern of benefit varied greatly across participants.

Educational objectives: The reader will be able to: (1) discuss recent research in altered auditory feedback that led to the development of SpeechEasy, (2) analyze and describe issues related to evaluating the treatment benefits of fluency aids, and (3) summarize the range of outcomes that were observed with SpeechEasy in this study.

Keywords: Stuttering; Fluency aid; Stuttering treatment outcome; SpeechEasy

Wearable electronic devices for treating stuttering have been commercially available since 1968 when a metronome under the brand name of Pace Master was introduced to the market

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(Westbrook, 1992). The electronic metronome was followed by a masking device (Edinburgh Masker), a vocal feedback device (Vocaltech Clinical Vocal Feedback Device), a device that provides aural enhancement of vocal tone (Fluency Master), and a device that delivers delayed auditory feedback (DAF), frequency altered feedback (FAF), and masking noise (Pocket Fluency System, Casa Futura Technologies).

SpeechEasy, a fluency aid that uses digital technology to deliver DAF and FAF, was introduced in 2001. In contrast to the above-mentioned devices which are large and therefore noticeable, SpeechEasy is small and can be worn inconspicuously. Similar in size, shape, and construction to digital hearing aids, these units are available in models that are either worn in the ear canal (ITC), completely in the canal (CIC), or behind the ear (BTE). The fluency aid has attracted considerable media attention (e.g., Good Morning America, NBC Nightly News, the Medical Miracles special of The Oprah Winfrey Show) with telecasts that have featured several individuals who exhibit an immediate and dramatic reduction in stuttering when wearing the device.

As with previous fluency aids, SpeechEasy was made available commercially prior to clinical testing of the device. In the absence of data from clinical testing of the device itself, the developers of SpeechEasy cited previous research on altered auditory feedback (AAF) as evidence that the device reduces stuttering (Janus Development Group, Inc., 2004). The work to which they refer began with Howell, El-Yaniv, and Powell's (1987) report of the stuttering reduction effects of an auditory feedback alteration called frequency-shifted feedback, which was found to be superior to those of masking and DAF. Subsequently, Kalinowski, Armson, Roland-Mieszkowski, Stuart,and Gracco (1993) examined stuttering reduction under three similar auditory feedback conditions: FAF, short delay DAF, and masking. For each auditory condition, nine participants read aloud at both normal and fast speech rates. These investigators found that stuttering reduced dramatically for FAF and DAF conditions at both normal and fast rates: Specifically, stuttering was reduced by 71% and 79% at a normal speech rate and by 87% and 81% at a fast speech rate in the DAF and FAF conditions, respectively. They concluded from these results that the stuttering reduction property of altered auditory feedback is not dependent on slowed speech, refuting a widely accepted idea first advanced by Wingate (1970, 1976) that speech rate changes induced by AAF are responsible for its fluency enhancing effects. Instead, Kalinowski et al. suggested that AAF may be an electronic form of choral speech; that is, DAF and FAF, like choral speech, involve a second speech signal.

Following their initial investigation, Kalinowski and co-workers carried out numerous other studies, investigating stuttering reduction as a function of a variety of variables including amount of delay or frequency shift, audience size, and whether AAF was delivered monaurally or binaurally. The speech task typically involved oral reading. Group results varied somewhat, but stuttering reduction generally stayed within a range of 50–85% (Armson, Foote, Witt, Kalinowski, & Stuart, 1997; Hargrave, Kalinowski, Stuart, Armson, & Jones, 1994; Kalinowski, Stuart, Sark, & Armson, 1996; Kalinowski, Stuart, Wamsley, & Rastatter, 1999; MacLeod, Kalinowski, Stuart, & Armson, 1995; Stuart, Kalinowski, Armson, Stenstrom, & Jones, 1996; Stuart, Kalinowski, & Rastatter, 1997). For example, Hargrave et al. (1994) found that the mean stuttering frequency for 14 participants was reduced by approximately 80% in four FAF conditions compared to a control condition whereas Stuart et al. (1996) reported that mean stuttering frequency for 12 participants was reduced by 50–60% for four FAF conditions. Kalinowski et al. (1996) found that stuttering was reduced for 14 participants by 70–76% for two DAF conditions.

Results of the aforementioned AAF studies were reported in terms of group effects and individual variability was not discussed in detail. However, the tables of raw stuttering frequencies presented in these reports indicate that degree of stuttering reduction varied substantially across individuals. This point is most evident in the study by Armson et al. (1997). Although this study reported a mean reduction of stuttering of 74% for nine adults who read aloud to audiences under FAF compared to a control condition, effects ranged from an extremely dramatic reduction for one participant (99%) to a small increase in stuttering under FAF for another (26%).

While the majority of AAF studies reported results primarily in terms of group effects for oral reading, two studies explored the effects of AAF on stuttering in formulated or spontaneously produced speech in addition to reading, and reported individual results for participants. Ingham, Moglia, Frank, Ingham, and Cordes (1997) explored the effects of FAF on four adults who stuttered during both oral reading and formulated speech. Results varied widely across individuals. One participant demonstrated a dramatic reduction in stuttering for both reading and formulated speech, a second exhibited a dramatic reduction in oral reading and a moderate reduction in formulated speech, while the third showed an inconsistent, modest reduction in reading and formulated speech. The fourth exhibited essentially no response to FAF in either context.

Armson and Stuart (1998) used a time series design to investigate the effect of FAF on stuttering for 12 participants during 10 min of oral reading and 10 min of continuously produced monologues compared to two 5-min baseline conditions. Group results revealed statistically significant reduction in stuttering under FAF compared to baseline conditions during reading, but there was no statistically significant reduction in stuttering under FAF for the monologue task. Analysis of individual responses showed varying patterns during reading with three participants demonstrating a large consistent reduction, six participants demonstrating an initial reduction followed by fluctuations in amount of stuttering, and three participants demonstrating essentially no change in stuttering frequency. However, inspection of individual profiles showed no reduction in stuttering for 10 of 12 participants during the experimental segment of the monologue task compared to baseline.

The results of the Ingham et al. (1997) and Armson and Stuart (1998) studies suggest that the effects of FAF may be more powerful during reading than formulated speech. These studies also reveal a more marked variation in response for reading than is implied by group analyses. Taken overall, then, results of AAF laboratory studies can be seen to provide an impetus for developing a miniaturized, wearable AAF device, though results also raise critical questions about the clinical application of AAF, specifically with respect to its benefits in formulated speech and the consistency of the effect across users.

It is also worth noting that the results of AAF research may not be directly generalized to SpeechEasy because of differences in technology and delivery methods. Previous laboratory studies used an advanced digital signal processor (Yamaha model DSP-1) while SpeechEasy uses a smaller, less powerful signal processor designed to fit inside a hearing-aid shell. Due to the current limitations in microprocessor technology, AAF algorithms cannot be implemented by miniature devices in the same way as larger, more powerful processors. In particular, the two systems use different algorithms to produce frequency alterations. In the original studies, the entire speech signal was scaled in frequency such that harmonic relationships between spectral components are preserved (Stuart et al., 1996) whereas with SpeechEasy, "the frequencies of signal components are moved by a fixed frequency increment" (Stuart, Kalinowski, Rastatter, Saltuklaroglu, & Dayalu, 2004, p. 98). When harmonic relationships are distorted, signal intelligibility is reduced, especially for large frequency shifts.

There are other differences between signal delivery methods used in the early research leading to SpeechEasy and in the SpeechEasy itself. In early research, insert earphones delivered the altered voice signal binaurally. In addition, most testing was conducted in a sound booth with very low ambient noise. As such, participants heard only their own altered voice signal. In contrast, SpeechEasy is expected to be worn monaurally in situations of daily living. The speaker hears his or her altered voice signal in one ear and receives other signals, including his or her own unaltered voice via the other. As such, other environmental sounds picked up by the device are altered including the voices of other speakers.

Clearly, there are substantial differences between delivery of AAF via SpeechEasy and the methodology employed by AAF studies conducted in the 1990s that led to its development. The impact of these differences on stuttering reduction is currently unknown. This issue indicates that extensive testing of the clinical application of AAF as delivered by laboratory equipment is not sufficient, and underscores the importance of direct clinical testing of SpeechEasy itself.

There are many questions about the clinical efficacy and effectiveness of SpeechEasy that need to be addressed over the long term. However, it seems reasonable to begin by specifically addressing the clinically related questions raised by the results of the AAF laboratory studies: Specifically, it is imperative to explore stuttering reduction effects in formulated speech as well as oral reading, given that the former is the context for which the device is intended. In addition, given that benefit from AAF is highly variable across individuals, it is important to ask the following questions: What proportion of a given population sample might be expected to receive a dramatic benefit from SpeechEasy? How many receive essentially no benefit at all? Such questions can be addressed when results are reported in such a way as to permit scrutiny of individual responses—information of potential use to professionals who are interested in assessing the therapeutic applicability of the device on a client-by-client basis.

The only published systematic study of the effect of SpeechEasy on stuttering frequency thus far is provided by Stuart et al. (2004).[1] In one experiment, they examined the effect of the device on stuttering frequency for seven participants at the time of initial fitting of the device and in a second experiment, they examined stuttering frequency for eight participants before and after a 4-month period of wearing the device. Speech samples included monologue as well as orally read speech. Stuart et al. demonstrated a substantial group reduction in stuttering frequency in monologue, or formulated, speech as well as for oral reading for participants using SpeechEasy under laboratory conditions (mean reductions of 67% and 90%, respectively). Similar results were found both at the time of initial fitting and four months later. It may be noted that a reduction of 90% for oral reading for SpeechEasy is slightly above the range of values previously reported for AAF in laboratory studies. Further, percent reduction for monologue speech was well within the same range suggesting a more robust effect for formulated speech with SpeechEasy than previously reported for AAF delivered by other technology. However, Stuart et al. did not report data for individual participants. Such information would be beneficial for clinicians and prospective recipients when assessing the effectiveness of the device, particularly given that variability was larger for the monologue task than for the reading task.

There is a need for further investigations of the clinical benefits of SpeechEasy that focus on its stuttering reduction properties in formulated speech. In addition, the variability of responses across participants should be examined. Therefore, one purpose of the current study is to examine the effects of SpeechEasy on stuttering during monologue speech and conversation as well as oral reading. A second purpose is to assess individual response profiles in addition to group analyses.

[1] SpeechEasy was not mentioned by name in the paper. Instead the fluency aid was described as “self-contained ear-level devices delivering altered auditory feedback” (p. 93). However, the specific description of the devices as well as reference to both Micro-DSP as manufacturers of device components and Janus Development as device distributor indicate that the aids are those sold under the tradename of SpeechEasy.

Table 1
Participant characteristics

Participant number	Age (years)	Gender	Time since treatment	Exposure to AAF	Education[a]
1	49	Male	20 years	No	College
2	25	Male	3 years	No	University
3	35	Female	Enrolled	No	Grade 8
4	26	Male	1 month	No	Grade 12
5	53	Male	18 years	Yes	University
6	24	Male	7 months	No	University
7	28	Male	18 years	Yes	University
8	54	Male	8 years	Yes	College
9	27	Male	15 years	No	College
10	24	Female	4 years	No	College
11	53	Male	No treatment	No	Grade 12
12	21	Male	4 years	No	University
13	40	Male	?	No	College

[a] "College" refers to programs for technical or trade training. "University" refers to degree-granting institutions.

A third purpose of the current study is to compare results obtained with the specific protocol used by clinicians dispensing the device with results obtained with procedures used in previous AAF laboratory research. The manufacturer's protocol includes instructions for clients to listen specifically to the altered speech signal, and also asks them to deliberately prolong sounds at the onset of breath groups (Janus Development, 2002). According to an explanation provided in Stuart et al. (2004), the intention of these speech pattern adjustments is to enhance the choral speech effect of the device. They observe that in order for a second signal to have stuttering reduction properties, this signal must first be produced, and state that "vowel prolongation and the use of starters (e.g., "um", "ah", etc.) . . . help initiate or maintain the second choral-like signal" (p. 98). However, the earlier AAF laboratory studies did not involve specific instructions for participants to focus on the altered signal or to alter their speech pattern by prolonging vowels. Therefore, the effects of SpeechEasy on stuttering frequency both with and without instructions to deliberately make speech pattern adjustments are investigated.

1. Method

1.1. Participants

Thirteen people who stutter (PWS) were recruited through speech-language pathologists practicing in the local area and from a list of people who had expressed an interest in participating in research pertaining to stuttering. Participants consisted of 2 females and 11 males, ranging in age from 21 to 54 years ($M = 35.3$ years). One participant was currently enrolled in therapy, and of the remaining 12, all but one person had received therapy in the past. Three participants had previous exposure to AAF through participation in earlier research. All participants exhibited normal hearing in both ears, defined as having hearing thresholds at or below 25 dB HL at octave frequencies from 250 to 4000 Hz, with the exception of one participant (Participant 5) who exhibited a threshold of 30 dB at 4000 Hz in his right ear. Given the small deviation from criterion, he was accepted for participation in the study. Informed consent was obtained from all participants. Table 1 provides a summary of the characteristics of each participant with respect to age, gender, treatment history, previous exposure to AAF, and level of education.

1.2. Apparatus

Each participant was fit with a programmable SpeechEasy Basic BTE unit. The BTE model is an external device that is worn behind the pinna and connects to a mold that fits in the ear canal. In this experiment, disposable canal tips (Comply, Hearing Components, Inc.) were used as temporary molds. Selection of right or left ear for fitting was based on participant preference.

SpeechEasy devices are programmed via an AudioPro interface (Micro-DSP). For this study, the SpeechEasy software version 1.1 was run on a PC which was connected to the AudioPro device via a serial cable.

SpeechEasy software permits manipulation of settings for three variables: FAF, DAF, and volume. With respect to DAF, the system permits programming of delays of 0–220 ms in 1-ms steps. For FAF, signal frequencies can be shifted linearly up or down in fixed increments of 500, 1000, 1500, and 2000 Hz. In addition to an external volume control, gain can be adjusted linearly in four 5-dB steps via the software. The default settings on the programming software were 60-ms delay, 500-Hz upward frequency shift, and volume setting of 2 which is defined internally. The signal can be spectrally shaped by independently adjusting attenuation up to 20 dB for eight frequency bands with center frequencies of 250, 750, 1250, 2000, 3000, 4000, 5250, and 7000 Hz. During this experiment, these gain controls were left at 0 dB attenuation.

Speech samples were recorded using a VHS video camera with built-in microphone. All testing was conducted in a quiet room.

1.3. Procedure

1.3.1. Design

Data collection for each participant began and ended with a baseline condition in which participants performed the speech tasks and did not wear the SpeechEasy device. Between the two baseline conditions, subjects performed the speech tasks while wearing a SpeechEasy device. There were two device conditions: Device Plus—which included instructions to participants to prolong vowels at the beginning of breath groups, consistent with the SpeechEasy fitting protocol (Janus Development Group, Inc. 2002)—and Device Only in which no such instructions were provided. This latter condition is consistent with procedures used in previous AAF laboratory studies. Rather than counterbalancing the order of the two conditions, Device Only always preceded Device Plus because of a potential carryover effect of instructions to prolong vowels; that is, once participants had been given such instructions, it would be impossible to ensure that they were not following them, even if instructed not to do so. The Device Plus condition therefore reflects the combined effects of the device itself and deliberate use of prolongation and was therefore expected to lead to greater reduction in stuttering than the Device Only condition.

1.3.2. Speech tasks

For each of the four conditions—the two baseline and two experimental conditions—participants produced speech in three contexts: oral reading, monologue, and conversation. Both monologue and conversation tasks provide an opportunity to evaluate stuttering reduction in spontaneously formulated speech. For the reading task, participants read aloud two 300-syllable passages taken from Grade 8 and 9 texts in social studies and science (Sims, 1987a, 1987b; Taylor, 1985). Participants read different passages for each condition. For the monologue task, participants were given a list of 10 general topics and asked to talk for 3 min about one of these or on any other topic of their choice. For the conversation task, participants engaged in discussion for 5 min with one experimenter. The experimenter took responsibility for ensuring that the participant consistently produced speech during the 5-min sample by asking a prepared set of questions when necessary. For most sessions, at least three people in addition to the participant were present—that is, two graduate students who administered the procedures and an experienced clinician.

1.3.3. Device fitting and speech sampling

For the device conditions, the manufacturer's protocol for device fitting was followed with respect to finding optimal DAF and FAF parameters for each participant (Janus Development Group, Inc., 2002). For the purposes of the fitting protocol, optimal was defined as maximum reduction in stuttering episodes as well as personal preference with respect to signal quality. Specifically, the steps were as follows: With the device in place in the ear and set at the default parameters (60-ms delay and +500-Hz frequency shift), participants were asked to sustain phonation of a single vowel for up to 1 min to help them adjust to the sound of the altered signal. Volume was adjusted to ensure that the signal could be easily heard. Next, participants were instructed to count from 1 to 20. Participants were then asked to read a series of short paragraphs while FAF and DAF settings were manipulated one variable at a time and an experimenter counted stuttering episodes on-line. FAF settings were manipulated first, with the DAF setting held constant at the default setting, until the experimenter and participant concurred that the optimal FAF setting had been found. Setting manipulations for FAF included changes in 500-Hz increments between +2000 and −2000 Hz. Then, holding the FAF setting constant at the newly identified optimal value, DAF settings were manipulated until an optimal delay was found. Delays of 30, 60, 90, and 120 ms were used. The DAF and FAF settings that were established as optimal for a given participant were used for both device conditions.

After optimal DAF and FAF settings were established, speech samples for Device Only were recorded. For Device Plus, participants were first given a brief training session in which they were instructed to prolong vowels at the beginning of each new breath and provided with models of the target behavior. The experimenter demonstrated the procedure and asked the participant to engage in a brief period of practice. Feedback was provided to help the participant follow the instructions. After approximately 5–10 min of practice, speech samples were recorded.

The baseline samples for both Pre-Device and Post-Device conditions were obtained before the device was placed on the participant and after it was removed, respectively. The entire session (including hearing screening and parameter optimization) took approximately 2–3½ h, depending on the amount of stuttering exhibited by the participant and the time required to find optimal parameter settings.

1.3.4. Stuttering counts

One of two graduate students in speech-language pathology counted stuttering episodes for each sample. Stuttering counts were made for the first 300 syllables of monologue and conversation samples, thus ensuring that sample length was consistent across conditions and participants. Both students had been trained to identify stuttering episodes by a clinician with over 25 years of clinical experience in the area of stuttering. Stuttering episodes were defined as part-word and word repetitions, part-word prolongations, and inaudible postural fixations. Stuttering frequency in percent syllables stuttered (%SS) was calculated for each passage using the stuttering count and total number of syllables for the passage. To assess interjudge reliability, the students recounted 12.5% of the samples: two of sixteen samples for each participant were chosen randomly for recounting. The student who had not counted stuttering episodes for the sample the first time did the recount. Interjudge agreement was estimated using Cohen's kappa (Cohen, 1988) for

Table 2
Mean stuttering frequencies (percent syllables stuttered)

Task	Pre-Device	Device Only	Device Plus	Post-Device
Reading	20.9	12.1	5.4	13.4
Monologue	18.2	12.8	11.6	15.3
Conversation	16.8	10.8	8.5	12.0

each speaker and ranged from .68 to .97 ($M = 0.85$; S.D. = 0.08). Spearman rank-order correlation coefficient for the two judges' estimates of %SS was .99.

2. Results

2.1. Group data

Mean stuttering frequencies for each speaking task and condition were calculated and are displayed in Table 2. Comparison of mean stuttering frequencies for Device Only and Device Plus with those for Pre-Device reveals reductions for all speaking tasks for both device conditions. For Device Only, stuttering reduced by 42%, 30%, and 36% and for Device Plus by 74%, 36%, and 49% for reading, monologue, and conversation, respectively.

Raw stuttering frequencies were arcsine transformed and differences across participants, task, and condition were evaluated using two-way repeated-measures analysis of variance (Table 3). There were highly significant differences for participant ($F_{12,124} = 32.4$; $p < .001$), speech task ($F_{2,124} = 6.6$; $p < .002$), and condition ($F_{3,124} = 25.54$; $p < .001$). The interaction of task by condition was not significant. Effect sizes as calculated using omega squared indicated a small effect size for *task* ($\omega^2 = .029$) and a medium effect size for *condition* ($\omega^2 = .108$) (Cohen, 1988). Although they were found to be statistically significantly different, effect sizes for main effects were tempered by large individual differences between subjects.

Planned post hoc analyses using Tukey's HSD ($\alpha = .05$) were conducted on simple effects of task and condition. With respect to task, reading was found to be significantly different from monologue and conversation, but monologue and conversation were not significantly different. With respect to condition, Pre-Device was significantly different from all other conditions. Device Only was significantly different from Pre-Device and Device Plus but not from Post-Device. Device Plus was significantly different from all other conditions. Post-Device was significantly different from Pre-Device and Device Plus but not from Device Only. In summary, results indicate that there was a significant effect for both device conditions relative to the Pre-Device baseline

Table 3
Analysis of variance

Source	SS	d.f.	MS	*F*	*p*
Participant	135.6	12	11.3	22.05	.001
Task	6.76	2	3.38	6.6	.002
Condition	25.54	3	8.51	16.61	.001
Task × condition	5.26	6	0.88	1.71	.12
Error	63.55	124	0.51		
Total	236.05	147			

Table 4
Stuttering frequencies for each participant by condition for the oral reading task

Participant	Pre-Device	Device Only	Device Plus	Post-Device
1	32.2	11.2	0.2	6.0
2	0.7	0.0	0.0	0.0
3	–	–	–	–
4	14.0	1.4	1.2	5.2
5	0.8	0.3	0	0.3
6	31.9	16.2	10.0	18.7
7	24.5	15.7	3.7	12.4
8	9.7	4.7	0.0	3.0
9	4.7	0.8	0.4	2.5
10	9.9	2.5	0.7	7.9
11	29.0	18.7	16.8	25.5
12	22.0	6.0	0.2	9.9
13	71.0	67.7	31.7	69.3

measure when data are collapsed across speech tasks. Further, there was a significant difference between Device Only and Device Plus. Additionally, only Device Plus was significantly different from Post-Device.

2.2. *Individual data*

Tables 4–6 show stuttering frequencies for each participant in each condition and speaking task. Fig. 1 presents the same information graphically. For Participant 3, data appears only for the conversation task because this participant was not able to read at a Grade 8 level and also had difficulty producing 3-min monologues.

Inspection of these graphs reveals that with the exception of Participant 13, all participants demonstrated some reduction in stuttering for both device conditions on at least one speech task, and typically on all three tasks. However, it can be seen that the benefit received was highly variable across tasks and across participants. With respect to between-task differences, the pattern

Table 5
Stuttering frequencies for each participant by condition for the monologue task

Participant	Pre-Device	Device Only	Device Plus	Post-Device
1	22.0	13.7	14.0	16.0
2	9.3	1.3	0.3	0.3
3	–	–	–	–
4	22.6	13.0	19.6	16.7
5	17.3	4.7	1.7	3.7
6	28.0	12.7	16.7	16.7
7	7.0	2.0	1.6	4.7
8	29.5	28.1	15.1	29.8
9	6.0	5.0	1.3	4.3
10	9.1	3.0	2.7	5.3
11	15.0	15.0	12.7	16.0
12	2.6	2.3	2.3	2.6
13	50.0	53.3	51.0	67.3

Table 6
Stuttering frequencies for each participant by condition for the conversation task

Participant	Pre-Device	Device Only	Device Plus	Post-Device
1	17.7	11.7	6.3	10.7
2	7.3	1.7	0.3	1.3
3	11.2	2.4	1.8	5.8
4	21.6	16.7	16.3	16.7
5	8.7	5.3	2.7	4.3
6	21.7	9.7	10.3	20.7
7	0.0	0.3	1.0	0.7
8	30.3	11.6	17.6	20.3
9	8.7	5.0	4.0	7.0
10	8.7	2.0	3.3	6.0
11	20.3	12.3	14.3	15.3
12	4.3	4.3	1.3	2.6
13	58.0	58.0	31.2	44.8

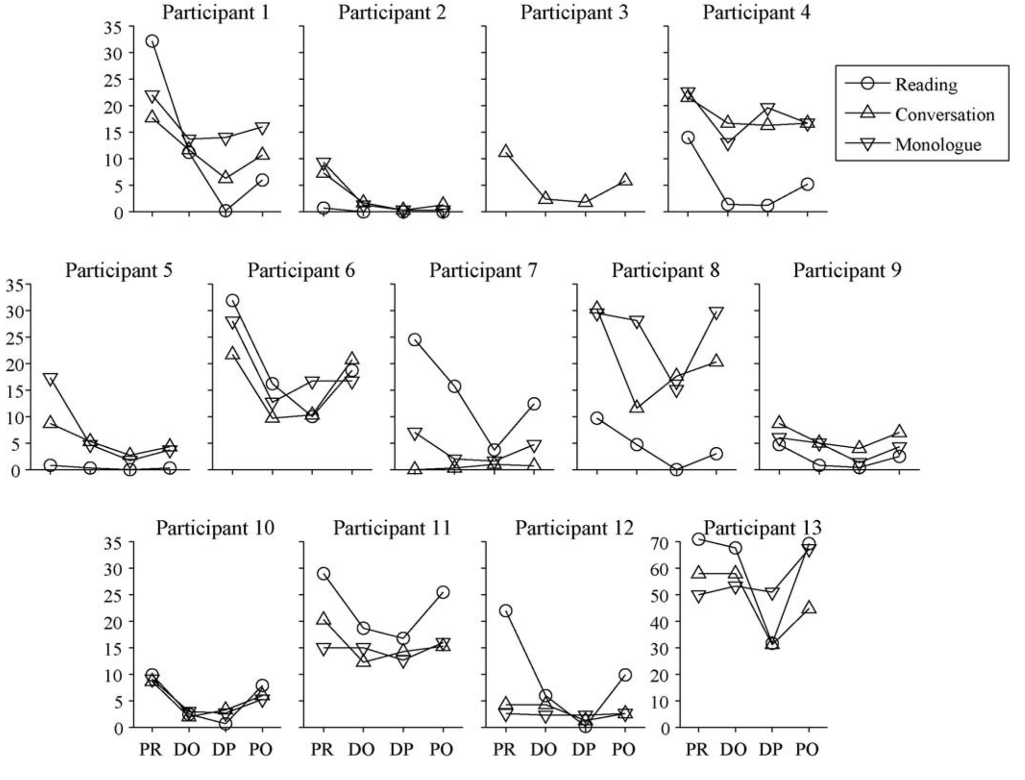

Fig. 1. Stuttering frequencies (percent syllables stuttered) for reading, monologue, and conversation tasks across conditions for each participant. PR: baseline or Pre-Device; DO: Device Only—participants received no instructions regarding vowel prolongation; DP: Device Plus—participants were instructed to use prolongation while wearing the device; PO: baseline or Post-Device. Participant 3 did not participate in the monologue or reading tasks. Note the different *y*-axis for Participant 13 who produced a substantially higher percentage of stuttered syllables than other participants.

of stuttering reduction for reading tended to differ from that for monologue and conversation (e.g., Participants 1, 4, 7, 8, 11, and 12). For these individuals, there was greater reduction in stuttering from Pre-Device to Device Only for oral reading than for formulated speech tasks.

With respect to stuttering reduction patterns during the monologue and conversation tasks, two major patterns are apparent: One pattern exhibited by seven participants (2, 3, 5, 7, 9, 10, 12) is characterized by minimal stuttering with the device in place during both device conditions, as defined by stuttering on 5% or less of syllables spoken. In general, these participants also exhibited relatively low levels of stuttering during baseline testing. With the exception of Participant 5 who produced 17% syllables stuttered during the monologue task, stuttering frequency for these participants was 11% or less during Pre-Device.

A second pattern was exhibited by five participants (4, 6, 8, 11, and 13) and is characterized by moderate–severe stuttering in conversation and monologue during device conditions, as defined by stuttering on 10% or more of syllables spoken. More specifically, Participant 4 exhibited stuttering frequencies in the range of 13–20% for monologue and conversation tasks across the two device conditions whereas stuttering frequency ranges for the two tasks for Participants 6, 8, and 11 were 10–17%, 12–28%, and 12–15%, respectively. Participants 4 and 11 showed minimal change in device conditions compared to the Pre-Device condition for monologue and conversation.

The patterns of Participant 13 warrant special attention. Participant 13 can be considered an outlier with respect to stuttering severity in that his baseline frequencies were 71%, 50%, and 58% for reading, monologue, and conversation, respectively. These stuttering frequencies are in the profoundly severe range and at a level rarely encountered in clinical practice. Participant 13 exhibited essentially no change in stuttering in Device Only compared to Pre-Device but with addition of prolongation in Device Plus, stuttering reduced to 32% and 31% syllables stuttered for reading and conversation, respectively—levels that are still considered very high.

With respect to a comparison of the effect of Device Only with that of Device Plus, it can be seen that apart from Participant 13, only a few participants showed a substantial added benefit following instructions to deliberately prolong vowels at the beginning of breath groups. For example, Participant 1 reduced stuttering frequency during oral reading from 11% in Device Only to 0 in Device Plus and during conversation from 12% in Device Only to 6% in Device Plus. Also for oral reading, Participants 6 and 7 reduced stuttering from 16% to 10% and 16% to 4%, respectively, when instructed to use prolongation. Smaller effects occurred for other participants across the three speech tasks, but a general tendency for the stuttering reduction effect to be dramatically enhanced in Device Plus was not observed.

It is also interesting to observe that four participants (3, 9, 10, and 11) exhibited a near return to baseline in the Post-Device condition. Two participants (2 and 5) exhibited approximately the same level of stuttering in the Post-Device conditions as for the device conditions for all three speech tasks. The remaining participants showed some increase in syllables stuttered in the Post-Device condition compared to device conditions in at least one speech task, but in most instances levels remained somewhat below those exhibited during the Pre-Device condition.

3. Discussion

The primary goal of this study was to investigate the possible stuttering reduction properties of the SpeechEasy device in a laboratory setting and to examine the role of the specific fitting protocol prescribed by its manufacturers. Stuttering reduction in monologue and conversation was of particular interest, given that formulated speech, rather than oral reading, is used in everyday speaking situations, and that the stuttering reduction properties of AAF may be less in formulated speech than in oral reading. Because it was also important to compare procedures followed by clinicians who dispense the device with procedures used in the previous AAF studies, two device conditions were used: Device Plus, in which participants were instructed to prolong vowels at the beginning of breath groups, and Device Only, in which no such instructions were given. Finally, results were reported both in terms of group effects, which permits comparison with results of previous AAF laboratory studies, and individual response profiles, which provides useful information to prospective clients and clinicians about possible responses on a person-by-person basis.

In general terms, results of this study indicate that, while wearing a SpeechEasy device, 13 adults who stutter exhibited a reduction in mean frequency of stuttering for the three speech tasks in both device conditions compared to a Pre-Device baseline condition. Statistical testing showed that mean stuttering frequencies for the two device conditions were significantly different from the mean stuttering frequencies for the Pre-Device condition for all speech tasks. Although mean stuttering levels increased in the Post-Device baseline condition relative to levels in the device conditions, they failed to reach Pre-Device levels, indicating some degree of treatment carryover effect. However, inspection of individual response profiles shows that stuttering increased noticeably in the Post-Device condition compared to device conditions for 11 of 13 participants for at least one speech task. In general, response patterns of stuttering frequency exhibited with and without the device support the conclusion that the stuttering reduction with the device in place was not a spurious effect or attributable to some artifact of the experimental situation such as increased comfort level as a function of time spent in the session.

With respect to the issue of relative benefit across speech tasks, results showed that a greater reduction in stuttering occurred for reading (i.e., 42% for Device Only and 74% for Device Plus) than for monologue (i.e., 30% for Device Only and 36% for Device Plus) and conversation (i.e., 36% for Device Only and 49% for Device Plus), differences that were statistically significant for reading versus both monologue and conversation. These results, therefore, support previous AAF research that reported a more robust fluency inducing effect for oral reading than for formulated speech. However, current data suggest a stronger stuttering reduction effect for formulated speech than reported by Armson and Stuart (1998) who found an effect for only 2 of 12 participants. In contrast, in the current study, 7 of 13 participants reduced stuttering by at least 37% during monologue speech in the Device Only condition (the device condition that is directly comparable to the previous study).

Percent reductions in stuttering for the two device conditions can be compared to values reported in the AAF research literature. In general, it can be observed that with the exception of a 74% reduction in stuttering for reading in Device Plus, percent values fell below the previously reported range of 50–85%. The most direct comparisons with previous AAF laboratory studies are for the reading task for Device Only, where a group mean reduction of 42% was found in the current study. Reductions in Device Plus for reading and monologue can be compared to findings reported by Stuart et al. (2004), who also instructed participants to use vowel prolongation, as described previously. The currently reported results of 74% and 36% for reading and monologue, respectively, are lower than Stuart et al.'s reported values of 90% and 67% for the same two speech tasks under similar conditions.

As predicted, mean values for percent reduction in stuttering were consistently greater for Device Plus than for Device Only, differences that were statistically different. Inspection of the individual response profiles shows that several participants exhibited a clear pattern of additional reductions in Device Plus, particularly for the reading task (1, 7, 8, and 12). It may also be noted that Participant 13 who experienced minimal change in stuttering in Device Only demonstrated a noticeable reduction in Device Plus compared to Device Only and Pre-Device for both reading and conversation. It was predicted that participant use of vowel prolongation at the beginning of breath groups would increase a stuttering reduction effect, given that prolongation is a core feature of most behavioral treatment programs for stuttering (e.g., see Guitar, 1998). However, an alteration in speech production pattern introduces a variable that confounds interpretation of the responses for Device Plus: Specifically, it is not possible to determine the relative contribution of vowel prolongation versus feedback alteration to the stuttering reduction effect. On the other hand, the fact that stuttering reduced under Device Only, before participants had been instructed to deliberately prolong vowels, demonstrates that use of vowel prolongation is not necessary for a benefit to occur.

It may also be noted that there was considerable variation across participants with respect to benefit received from the instructions to alter their speech patterns. Such variation may simply mean that participants differed considerably in their compliance with the instructions, given that meeting a criterion level of performance was not required. Clearly, there are numerous issues associated with the use of instructions to alter speech production patterns for fitting SpeechEasy that should be addressed in future research, but these issues go beyond the scope of the present study.

With respect to individual participant profiles, all participants showed some degree of stuttering reduction during one or both device conditions in at least one of the three speaking tasks. Inspection of the graphs, however, reveals considerable variability in benefit across participants. Consistent with group results, some participants exhibited different patterns for reading than for formulated speech. While some of these patterns defy clear categorization, the most consistent tendency was for a noticeably stronger, more dramatic effect in reading than for formulated speech (e.g., Participants 1, 4, 7, and 12). In contrast, a few participants exhibited essentially the same patterns for all three tasks (i.e., Participants 2, 6, and 10). When formulated speech is considered specifically, four participants (2, 3, 5, and 10) demonstrated patterns that unambiguously show benefit, in that they exhibited a low level of stuttering during device conditions and demonstrated a noticeable reduction from baseline to device conditions. Not surprisingly, they (along with Participant 1) commented on the noticeable benefit and expressed interest in the device. In contrast, five participants (4, 6, 8, 11, and 13) exhibited stuttering levels that varied from 10% to 31% for monologue speech and conversation across device conditions. These participants experienced moderate to severe levels of stuttering during production of formulated speech in the Pre-Device baseline condition. Averaged across monologue and conversation tasks, initial baseline levels of stuttering for Participants 4, 6, 8, 11, and 13 were 22%, 25%, 30%, 17.5%, and 54% syllables stuttered, respectively. While several of these participants experienced some degree of reduction, it is interesting that most seemed relatively unaware of a benefit and some expressed considerable disappointment at the outcome.

In summary, the current study indicates that DAF and FAF delivered via SpeechEasy resulted in some stuttering reduction during at least one of three speech tasks for 13 participants. While group results showed that stuttering reduction was greater for reading than for formulated speech, stuttering frequencies were found to be significantly different for all speech tasks in device compared to baseline conditions. Stuttering reduction was not dependent on use of vowel prolongation although results suggest that deliberate application of this speech production pattern could potentially enhance the effect. An important finding of the current study was that degree and pattern of benefit varied greatly across participants. Although a few participants exhibited both a dramatic reduction in stuttering and relative freedom from stuttering in the device conditions, others showed a modest or minimal reduction and continued to exhibit a relatively high level of stuttering.

Further investigations into the treatment outcomes of SpeechEasy are warranted. It is of interest to examine the responses of a large number of people who stutter under laboratory or clinical conditions of device use and ultimately arrive at a reliable figure that represents the proportion who may be expected to gain substantial benefit. It is also important to study treatment outcomes under everyday conditions to determine whether the effect is generalized to those conditions and can be maintained over time. While SpeechEasy may not be the miracle cure that many people who stutter hope for, it seems apparent that it (or devices like it), may extend the number of treatment possibilities available to people who stutter and therefore warrant serious, though cautious, consideration by the professional community.

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CONTINUING EDUCATION

The effect of SpeechEasy on stuttering frequency in laboratory conditions

QUESTIONS

1. Based on findings from the 1990s research literature on the stuttering reduction properties of AAF, which one of the following statements is *not* true?
   a. AAF was found to be associated with stuttering reduction only when the speaker uses a slow speech rate
   b. both FAF and DAF were found to be more effective in reducing stuttering than masking
   c. most studies of the group effects of FAF and DAF employed oral reading rather than formulated speech tasks
   d. studies using a single-subject design suggested that stuttering reduction properties were greater in oral reading than formulated speech
2. In this laboratory study of SpeechEasy, the most dramatic reduction in stuttering frequency was demonstrated for which one of the following speech tasks:
   a. conversation
   b. monologue
   c. reading
   d. telephone
3. Select the statement that best describes the outcome results of the current study under laboratory conditions:
   a. all participants exhibited a dramatic decrease in stuttering in the device conditions for all speech tasks
   b. the majority of participants exhibited a dramatic decrease in stuttering in the device conditions for at least one speech task
   c. participants showed minimal or no reduction in stuttering in the device conditions for any of the speech tasks

   d. participants exhibited a wide range of responses in the device conditions, ranging from minimal to no reduction to a marked decrease in stuttering
4. In this study, speech samples were obtained after participants were instructed to deliberately prolong vowels at the beginning of breath groups, consistent with the manufacturer's protocol, and before such instructions were given, consistent with procedures used in previous research. Group results showed:
   a. stuttering reduced only when participants were instructed to prolong vowels
   b. stuttering reduced only when participants were not given any instructions to prolong vowels
   c. stuttering reduced in both conditions to the same degree
   d. stuttering reduced more in the condition involving instructions relative to the condition without instructions, but the difference was not significant
5. There are similarities and differences between the technology and signal delivery methods of SpeechEasy and those *typically* used in the AAF studies that led to its development. Indicate which of the following is the same for both SpeechEasy and previous technology and signal delivery methods for AAF:
   a. monaural presentation of the altered speech signal
   b. algorithm for FAF
   c. optimization of FAF and DAF parameters for individual users
   d. small and portable piece of equipment
   e. none of the above

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