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The SpeechEasy device in stuttering and nonstuttering adults: Fluency effects while speaking and reading

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ABSTRACT

The SpeechEasy is an electronic device designed to alleviate stuttering by manipulating auditory feedback via time delays and frequency shifts. Device settings (control, default, custom), ear-placement (left, right), speaking task, and cognitive variables were examined in people who stutter (PWS) (n = 14) compared to controls (n = 10). Among the PWS there was a significantly greater reduction in stuttering (compared to baseline) with custom device settings compared to the non-altered feedback (control) condition. Stuttering was reduced the most during reading, followed by narrative and conversation. For the conversation task, stuttering was reduced more when the device was worn in the left ear. Those individuals with a more severe stuttering rate at baseline had a greater benefit from the use of the device compared to individuals with less severe stuttering. Our results support the view that overt stuttering is associated with defective speech-language monitoring that can be influenced by manipulating auditory feedback.

1. Introduction

Developmental stuttering is characterized by involuntary repetitions, prolongations, and blocks in the utterance of speech elements, including sounds, syllables, and words. Developmental stuttering impacts the social, academic, and vocational achievements of an estimated 1.5 million Americans, including 4% of children and 1% of adults. Although a range of clinical practices and therapeutic strategies are used to treat stuttering, many people who stutter (PWS) continue to have difficulty communicating throughout their lives (for review, see Bloodstein & Ratner, 2008; Van Riper, 1971). The efficacy and effectiveness of various treatments for stuttering remain a source of vigorous debate and investigation including an interest in linking treatment strategies to central neural mechanisms (Foundas et al., 2004; Howell, 2004; Watkins, Smith, Davis, & Howell, 2008).

One treatment approach that has received considerable attention is the use of a "second speech signal" to alter auditory feedback so that a speaker's vocal output is perceived by the speaker in a manner that differs from an unaltered or baseline speaking condition. Second speech signals can be choral, shadowing, temporally delayed, or shifted in frequency (Howell & Powell, 1987; Kalinowski, Armson, Roland-Mieszkowski, Stuart, & Gracco, 1993; Lincoln, Packman, & Onslow, 2006; Natke and Kalveram, 2001). In the conditions of choral reading and shadowing, a person listens to and reads or speaks along with another person (Cherry & Sayers, 1956). Under the effects of externally-delayed auditory feedback (DAF) and frequency-shifted feedback (FSF), the speaker listens to his/her own speech production that is electronically changed with the use of small-in-the-ear devices. In the case of DAF, the speech is amplified and delayed (alteration in the time domain), whereas FSF shifts the whole spectrum of speech. Each of these parameters can be experimentally manipulated to identify the effectiveness of specific frequency shifts or timing delays in individual clients or in groups of people who stutter (Howell, 2004; Lincoln et al., 2006).

Early studies investigating DAF used a long temporal delay (>100 ms) and reported that PWS were more fluent compared to baseline, although their speech was produced with greater effort and speaking rate (Goldiamond, 1965; Harrington, 1988). More recent DAF studies used a shorter delay (50–60 ms) and found speakers were able to maintain a faster speaking rate while still improving their speech fluency (Kalinowski & Stuart, 1996; Sparks, Grant, Millay, Walker-Batson, & Hynan, 2002). Studies investigating prolonged daily use of DAF have shown an immediate reduction in stuttering rate across speaking tasks with the benefit maintained over three months (Van Borsel, Reunes, & Van den Bergh, 2003). Likewise, FSF can effectively reduce stuttering rate, including the finding that FSF is more effective than DAF (Howell,

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El-Yaniv, & Powell, 1987), although this result has not been reported in some studies (Kalinowski et al., 1993; Stuart, Kalinowski, & Rastatter, 1997; Zimmerman, Kalinowski, Stuart, & Rastatter, 1997). A study that compared non-altered feedback (NAF), DAF, FSF and a combination of DAF and FSF showed that stuttering rate was significantly reduced during all conditions, although there was no added benefit found with the combined use of DAF and FAF under laboratory conditions (Macleod, Kalinowski, Stuart, & Armson, 1995). The freqency of stuttering was also found to be significantly reduced in the NAF condition supporting the idea that there may be either a placebo effect or affects of amplification. Although results from multiple studies found DAF and FSF enhanced fluency in PWS, individual benefits vary and many PWS show only modest improvements in speech fluency (Armson, Foote, Witt, Kalinowski, & Stuart, 1997; Hargrave, Kalinowski, Stuart, Armson, & Jones, 1994; Howell, 1990, 2004; Howell & Powell, 1987; Kalinowski, 2003; Kalinowski et al., 1993; Lincoln et al., 2006; Macleod et al., 1995; Stuart, Kalinowski, Armson, Stenstrom, & Jones, 1996; Stuart et al., 1997; Zimmerman et al., 1997).

In recent years, a small in-the-ear prosthetic aid, named SpeechEasy, has been designed and marketed in attempts to alleviate stuttering by manipulating auditory feedback via DAF and FSF (SpeechEasy device, Janus Group, Inc., 2001). According to the SpeechEasy's associated marketing literature, such altered auditory feedback adjustments mimic the effects of choral reading. The effects of choral speech are nearly universal across PWS and, therefore, this therapeutic technique is considered the most powerful temporary condition of stuttering amelioration every identified (Bloodstein & Ratner, 2008). The effects of the SpeechEasy device on stuttering frequency, self-ratings, speech naturalness and speech rate have been empirically studied in single case reports (Kalinowski, 2003; Kalinowski, Guntupalli, Stuart, & Saltuklaroglu, 2004), and in several laboratory studies (Armson & Kiefte, 2008; Armson, Kiefte, Mason, & De Croos, 2006; Kalinowski, 2003; O'Donnell, Armson, & Kiefte, 2008; Stuart, Kalinowski, Rastatter, Saltuklaroglu, & Dayalu, 2004; Stuart, Kalinowski, Saltuklaroglu, & Guntupalli, 2006) with promising results in some adults with persistent developmental stuttering. In one of the first controlled laboratory studies, the SpeechEasy was examined in a sample of 11 men and 2 women who stutter (Armson et al., 2006). Participants were examined at baseline (no device in-the-ear) and with the device in place in the preferred ear. The manufacture's protocol was followed in attempts to derive optimal DAF and FSF settings for each participant. Two conditions were tested including the use of the device without any speaking instructions (*device only*), and another condition with the instructions to deliberately prolong vowels (*device plus vowel prolongation*) while speaking. Percent stuttered syllables was measured in three different speaking tasks (relative to a baseline condition), with 36%, 30% and 42% reduction respectively for the conversation, monologue, and reading conditions (device only). Individual profiles showed considerable variability, however, all participants showed some improvement during one or both device conditions in at least one of the three speaking tasks. Overall, fluency was more enhanced with the instruction to deliberately prolong vowels, which slows speaking rate and requires more attention to speech articulation; suggesting that factors other than altered auditory feedback (e.g., vocal intensity or level, speaking rate) may be driving the enhancement of fluency.

The effectiveness of the SpeechEasy device has also recently been evaluated in real-world situations with mixed results (O'Donnell et al., 2008; Pollard, Ellis, Finan, & Ramig, 2009). Conversational speech was examined over a 16-week period in seven adults who stutter (five men, two women) using a multiple single-subject design with laboratory assessments conducted at the beginning and end of the study (O'Donnell et al., 2008). Five of the seven participants (71%) had some reduction in stuttering rate compared to baseline fluency, and three of seven (43%) had a stable reduction in stuttering over time. The second study used a nonrandomized group design to evaluate adults who stutter (six men, five women) who were prescribed the device for use in day-to-day interactions over four-months (Pollard et al., 2009). Despite the relatively large standard deviations across speaking conditions, half of the participants showed a significant change from baseline in at least one speaking condition with a persistent benefit in 20% of the participants. The effects were more pronounced during reading than during conversational speech consistent with those reported in the laboratory setting (Armson & Stuart, 1998; Armson et al., 2006; Ingham, Moglia, Frank, Ingham, & Cordes, 1997). Ear effects and sex-linked factors were not controlled nor evaluated as potential confounds in any of these studies, and different device settings were not compared within subjects (O'Donnell et al., 2008; Pollard et al., 2009).

Some investigators have speculated that the SpeechEasy device is not therapeutically useful (Pollard et al., 2009), and there continues to be vigorous debate about its efficacy and effectiveness (Saltuklaroglu, Kalinowski, & Stuart, 2010). It is important to note, however, that prior studies did not include a NAF (control) condition nor were effects of ear placement systematically evaluated. There is also a limited understanding of the means by which stuttering changes as a result of alterations in speakers' air-borne auditory feedback. Thus, given the number and nature of issues still unresolved regarding altered auditory feedback effects and stuttering, we initiated an empirical study to assess how this device influences fluency in adults with persistent developmental stuttering, as well as the extent to which device settings and ear placement contribute to this influence. All participants served as their own control because experimental conditions were compared to baseline fluency measured before the device was inserted in the ear-canal, with the order of ear-placement randomized.

The current study evaluated a change in fluency using *two different device settings* (experimental conditions) that manipulated the delay and frequency setting. One of the device setting conditions was the manufacturer recommended-default setting with a 60 ms delay and the frequency shifted up 500 Hz. These settings are the starting point for the fitting of the device to determine "individualized-prescribed settings." Therefore, the other device condition was based on having each study participant undergo this type of "prescriptive" fitting in the laboratory setting (before the procedures were initiated) in order to individually determine each participant's preference for setting the DAF and FSF (volume was determined based on the most comfortable setting). Thus, this condition simulates the clinically prescribed fitting of the SpeechEasy and replicates one of the procedures used previously (Armson et al., 2006).

However, there are other differences in our study design. First, we added a *control condition* defined as having the device in-the-ear-canal with amplified auditory feedback but with no delay or frequency alteration in the audio-vocal feedback. This condition is not purely a placebo controlled condition because the speech is amplified, there is a very brief delay in the audio-vocal feedback (10 ms), and there is a potential effect of bone conductance/ear-occlusion as well. Second, we independently evaluated the effects of ear-placement. The manufacturer originally specified that the client should use the device in the right ear and later changed the recommendations to stipulate that the client should use the device in the preferred ear. Third, each study participant was instructed to speak naturally without any intended use of active techniques to alter speech patterns. Another major difference is the method used to compute stuttering rate. Unlike previous studies (Armson & Stuart, 1998; Armson et al., 2006; Ingham et al., 1997), we did not compute stuttering frequency as a percentage