Introduction

Stuttering, the debilitating disorder of communication, afflicts approximately 3 million people in the United States and 60 million people worldwide. It develops during early childhood and though its preliminary involuntary manifestations may appear to be relatively innocuous, it often develops into a debilitating condition that permeates and negatively impacts nearly every aspect of human interaction. When children first begin to display characteristic stuttering behaviors such as sound, syllable or word repetitions or prolongations, silent blocking on speech sounds, visible facial or
laryngeal tension, or any other behavior that is indicative of a struggle to produce speech, parents often turn first to physicians for help and advice. However, the cause of stuttering is still unknown and aside from those children whose developmental course allows them early spontaneous recovery, those afflicted seem to display stuttering symptoms throughout the remainder of their lives. Despite the availability of early intervention for the last 70 years, the overall prevalence of stuttering has remained stable. Therefore, at this time the goal for treatment should be effective and efficient symptom management. We suggest that the treatment of stuttering should suppress the symptomatology sufficiently, so as to allow the person who stutters to communicate in as similar fashion as possible to someone who does not stutter (i.e., to produce natural sounding, unimpeded speech). Furthermore, this goal should be accomplished in the shortest time, with the least amount of effort expended, and produce the most longstanding reduction of symptoms (i.e. years rather than months).

While the dedication of clinical practitioners and researchers towards this goal cannot be questioned, the options for accomplishing effective and efficient symptom management have been limited in the past. Generally, each approach employed has been an offshoot of a dominating psychological paradigm. As such, for the last 40 years or so, operant behavioral therapies that implement systematic ‘speech retraining’ strategies have predominated over all other forms of therapeutic intervention. While these therapies have helped some, it seems safe to state that people who stutter want and need other therapeutic options that can truly meet the criteria for effective and efficient symptom management.

With technological advances, a new, ‘digital’ paradigm may be paving the road to improvements in stuttering symptom management. Recently, the first generation of prosthetic ear-level devices (e.g., the SpeechEasy*) has become available. These devices employ the well-documented effects of ‘altered auditory feedback’ (AAF), to inhibit stuttering. Rather than focusing on speech retraining, the user is provided with digitally created, online temporal and pitch shifts in the perception of their own voice. Such alterations in auditory feedback create the illusion of a second speaker, speaking in unison with the person who stutters. It is known as a ‘choral effect’ and has long been known to immediately and almost completely inhibit stuttering in almost everyone who stutters. The SpeechEasy is the first operational device to make use of digital technologies and miniaturization to help create the illusion of a second speaker to benefit those who stutter. Harnessing this inhibitory power may indeed present the next logical step in the management of stuttering. Speech pathologists are fast becoming aware of this new treatment option, and as physicians are often sources of referral, we believe that they should also be in possession of information regarding these treatment options. We will review pertinent information regarding the disorder and highlight some of the points to consider when choosing among the available therapeutic options.

Stuttering in children: a few words of caution

The onset of developmental stuttering is usually between the ages of 2 and 6 years. The incidence of stuttering behaviors being found in children is approximately 5%, considerably higher than the 1% prevalence of the disorder in the general population. These figures appear to be consistent across cultures and do not appear to have changed over time, even with the advent of speech therapy. They simply suggest that about 80% (i.e., 4 out of 5) of all children who are diagnosed with stuttering will recover. Most physicians are aware of these statistics and therefore provide positive prognoses to parents seeking help for young children beginning to demonstrate stuttering behaviors. However, among the 5% of children who may be classified as displaying stuttering or ‘disfluent’ speech behaviors, a great deal of symptomatic variability exists. Among the milder behaviors are simple tension-free phrase and word repetitions or revisions that often go unnoticed by the child, have little impact on communication, and may or may not be a source of concern to the caregiver. At the more severe end of the spectrum of preliminary disfluent behaviors are repeated sound or syllable repetitions that may rapidly develop into sound prolongations or even silent blocks accompanied with tension, struggle and visible frustration as the ability to communicate becomes increasingly impaired.

However, with stuttering, no ‘biopsy’ can be performed on the early symptoms. Even with the range of early symptomatic variability, no behavioral predictor of recovery has ever been revealed to separate the 80% who will recover from the 20% (i.e., 1 out 5) who will continue to stutter. In other words, after 70 years of study and immense efforts spent attempting to uncover a behavioral predictor, no subset or characteristic of overt behaviors has emerged that separates ‘benign’ from ‘malignant’ forms of early stuttering. Furthermore, as stuttering is the result of an involuntary block emanating from a ‘central’ origin, it seems highly unlikely that a predictor of recovery will ever be found in its behavioral, perceptual, or acoustic attributes. However, generally speaking, the chances of recovery become less likely as the initial symptoms and their impact upon communication become more severe.

* SpeechEasy is a registered trademark of the Janus Development Group, Inc., Greenville, NC 27834, USA
Many parents are understandably dissatisfied to simply remain hopeful that the odds of recovery are in their child’s favor and seek some form of clinical intervention. Indeed, it would seem better to err on the side of caution and provide intervention even though a given child may recover without treatment. Early intervention makes logical sense. Treating any pathology in its incipient stages seems more likely to result in success than treatment at a later stage. However, we feel it is necessary to use caution when assessing the claims of success by those who provide early intervention for stuttering. Today, most speech therapy for stuttering children directly targets motoric patterns of articulation, phonation and breathing in order to make the child aware of the speech difficulties and ‘teach’ the child how to speak without stuttering. This direct motoric treatment strategy stands in stark contrast to the approach that preceded it. From the 1940s and into the early 1980s, many believed that stuttering was caused by calling attention to the disorder and ‘labeling’ a child as a ‘stutterer’. To treat the disorder under this psychodynamic approach, parents were simply advised to ignore disruptive speech behaviors, pretend that the disorder did not exist, and most importantly, avoid labeling the child. These two dichotomous approaches have both claimed approximately 80% success rates in ameliorating stuttering in children; claims that are probably inflated, considering the potential for natural or spontaneous recovery. Furthermore, the prevalence of stuttering in the general population has never seemed to diminish. If early intervention for stuttering was truly ‘curing’ children of the pathology, we would expect the general prevalence of the disorder to be diminishing, especially in Western cultures where stuttering behaviors are identified early and speech therapy is readily available. Thus, is it not possible that early intervention for stuttering has claimed success for those children that otherwise may have recovered without therapy? Furthermore, should not the standard for therapeutic success in children be set at higher levels to account for those who would not otherwise recover without intervention?

As the prevalence of stuttering in the general population remains stable, it seems apparent that early intervention is failing to cure stuttering. In fact, we suspect that in many cases, even after leaving therapy speaking relatively fluently, children may relapse at a later stage if they are among the 20% for whom spontaneous recovery does not come into play. Parents and physicians should be wary of practitioners who take credit for curing stuttering children. However, the role of speech therapists in early stuttering intervention should not be negated. By implementing effective forms of symptom management, service providers can play a pivotal role in helping children who stutter cope with their communicative impairment. Along with educating parents about stuttering, counseling, and managing the psychological impact of stuttering, speech pathologists can provide the keys to reducing the characteristic speech disruptions that are the sources of all other visible and covert symptoms.

**Stuttering in adolescents and adults**

For those who continue to stutter past childhood, the chances of recovery appear to be slim, regardless of the number of years of continued therapy. By this time, especially in more severe cases, the disorder is often marked with longer and more tension-filled blockages of speech, as well as secondary behaviors such as facial grimacing, nostril flaring, rolling of the eyes, tongue protrusions, and any number of other bodily contortions. Furthermore, the pathology usually begins to assume a more syndrome-like nature with widespread negative psychological concomitants such as word, sound, or situational avoidances, and feelings of helplessness, inadequacy, anxiety, and nervousness that are likely to impede all facets of life. Oftentimes, adolescents and adults who stutter will have a history of therapy and if they are seeking further help, it is generally because they are dissatisfied with its outcome, possibly because their stuttering has proven to be highly resistant to treatment. Another alternative is that they have succumbed to relapse, which often occurs shortly after the completion of operant behavioral therapies for stuttering. Simply put, adolescents and adults who stutter and seek therapeutic intervention have typically lacked an efficient and effective way to manage their symptoms. It remains doubtful that repeatedly employing the same techniques will result in any further progress towards this goal.

**Therapeutic options**

**Behavioral Methods**

The question that remains is how best to implement effective and efficient symptom management for children and adults who stutter? Over the years, various methods for reducing stuttering frequency have been tried. Included in the outdated methods are placing rocks in the mouth (e.g., Demosthenes), radical glossectomies (e.g., Dieffenbach), binding a limb in attempts to reverse cerebral dominance (e.g., Travis), and Freudian psychoanalysis. These methods all failed miserably in eliminating stuttering and are infamous examples of truly inefficient and ineffective therapy procedures. Later, Skinnerian behaviorism gained popularity with the
assumption that any human behavior could be brought under voluntary control. Speech was no exception to this line of thinking, and whether it was believed that stuttering was due to ‘poor speaking habits’ or due to a discoordination in speech motor dynamics, most treatment methods consisted of retraining the speech system for the purposes of instilling and ingraining ‘corrected’ speech patterns. The simple observation of stuttering behaviors seemed to logically support this approach. It appeared that stuttering was a surface level disorder of the speech periphery (i.e., lungs, larynx, and speech articulators), and by making changes to the manner of speech production, normal or fluent speech could be effectively restored. Within this behavioral paradigm, two distinctive approaches emerged that could be administered either intensively or over extended time periods. Intensive therapies often consisted of one hundred or more therapy hours over about a 1-month period. In an extended schedule, therapies were administered on a weekly, twice weekly, or thrice weekly basis, for months or years on end.

The first approach, ‘stuttering modification’, made popular by Van Riper, consisted of identifying and modifying moments of stuttering in order to desensitize one to stuttering behaviors and confront the fears of stuttering. Having confronted their pathology, therapy recipients were taught to voluntarily produce stuttering episodes in an easier and less tense fashion, similar to normally occurring mild speech disruptions, in an effort to ‘control’ the involuntary pathology. Though this method achieved some success in reducing the frequency and severity of speech disruptions as well as learning to cope with the disorder, its appeal was limited. Stuttering modification involved a truly artful and introspective confrontation of the disorder, requiring those who stutter to face the behaviors from which they had spent years trying to escape. Further, in order to administer stuttering modification therapy, potential clinicians were required to spend long hours in the Van Riperian school, learning specialized methods that were non-standardized and to be administered on an individual basis. Though somewhat effective, its inefficiencies lay in its restrictive nature and limited appeal. That is, it was difficult to administer, used non-standardized methods, and required numerous hours of therapy. Its appeal was limited by the highly emotional content of therapies, which resulted in high drop out rates and many who simply did not wish to partake in such emotionally exhausting exercises.

In contrast to stuttering modification, ‘fluency shaping’ methods offered standardized protocols that were easy to learn and administer, making them readily available to the community of speech therapists seeking to help those who stutter. It was to be the next step in treating stuttering under the behavioral paradigm. Fluency shaping employed simple learning theory. It assumed that with continued practice, speech could be ‘reprogrammed’ in those who stutter, allowing fluent speech patterns to supplant stuttering behaviors. The therapeutic focus shifted from confronting stuttering to the production of fluent speech, making it appealing to vast numbers of potential clients as well as therapists. Furthermore, researchers began to examine physiological differences between fluent and stuttered speech, citing kinematic differences in phonation, breathing patterns, jaw and lip movements, and articulatory trajectories. These differences were taken to indicate a basic deficit in the ability to coordinate the motor speech structures. However, problems in interpreting these data never allowed for adequate separation between causes of stuttering and effects of stuttering.

Fluency shaping still consists of a complete retraining of all speech output with the goal of eliminating overt stuttering behaviors (i.e., repetitions and elongations of speech sounds). Using these methods, the overall rate of speech production is drastically reduced, so that ‘correct’ coordination between the lungs, larynx and articulators can be supposedly established. Numerous empirical data sets have been published to support the reduction of stuttering frequency via the use of behavioral therapies. However, we again advise interpreting these data with some caution. Behavioral therapy techniques are difficult to continuously implement as they require bringing an involuntary pathology under sustained volitional control. This exercise requires rigorous monitoring of speech, can be tiring and, is often unsuccessful. While therapeutic techniques can often be easily implemented in clinical settings and even on subsequent returns to the clinic after therapy where a patient feels comfortable, they are often difficult to implement in everyday speaking situations. They seem to fail most when needed, often cascading towards total relapse. Also, due to the changes in speech production that are caused by the use of behavioral techniques, the resultant speech often possesses an unnatural flavor, especially in more severe cases of stuttering. It can be both uncomfortable to use and listen to in everyday speaking situations. This is another reason that relapse rates from such methods continue to exceed 70%. Hence, even though fluency shaping gained wider popularity than stuttering modification due to standard protocols, ease of administration and wide availability, its effectiveness is compromised by the artificial sound that it generates and the propensity for relapse. Furthermore, the difficulty with generalization of skills is suggestive of a continued need for more efficient and effective methods.

Altered Auditory Feedback

Another means of establishing fluent speech in those who stutter is the use of altered auditory feedback (AAF).
Delayed auditory feedback (DAF) creates the perception of a slight temporal delay (e.g., 25–100 ms) when hearing one's own voice. In frequency altered feedback (FAF), the perceived alteration is a slight shift in pitch (e.g., 1/4 to 1 octave). Empirical studies have shown immediate reductions in stuttering episodes across participants by up to 88%. This effective reduction in stuttering is accomplished efficiently, with minimal training and with little or no compromise to speech naturalness. Thus, the reduction in stuttering has been attributed to a central 'inhibition' of the involuntary stuttering block. Altering the auditory feedback is thought to emulate 'choral speech', the most well known and effective stuttering inhibitor. Choral speech is simply speaking in unison. When people who stutter speak the same material with another speaker, they almost invariably become fluent. It is not surprising that the use of AAF has been found to immediately reduce stuttering in a variety of speaking situations including reading, conversation, speaking in front of an audience, and using the telephone. Furthermore, it has also proven to be effective when provided in only one ear.

The effects of AAF on stuttering have been known for over 50 years. Electronic devices that produced these effects were only available in bulky, conspicuous models with external headphones and wires that drew a great deal of unwanted attention. Nowadays, the availability of digital technology ear-level, inconspicuous and portable devices warrants consideration of these types of auditory conditions as options for stuttering therapy. It should be noted that DAF has been used in the past as a part of therapeutic protocols for stuttering. However, due to the long temporal delays used (e.g., 200 ms and higher), its use was limited to effectively helping establish 'prolonged speech', the cornerstone of most fluency shaping therapies. We now recognize that it is the alterations in auditory feedback that provide the inhibition of stuttering and that prolonged speech, though sufficient to inhibit stuttering, is not necessary, especially if the resultant speech is intended to sound natural. The effects of FAF have been known since 1987. This powerful effect shows a strong semblance to choral speech as the perceived auditory pitch shift and has been reported to sound like a second speaker, speaking in unison. Again, due to large, bulky devices that provided the effects of FAF, it was never considered a clinically viable form of stuttering therapy. However, Reed and Howell made a case for incorporating FAF into response contingent operant therapies, although they refrained from stating explicitly how this may be accomplished.

Used in isolation, AAF is a powerful choral speech emulator. Its effects are immediately observed in both children and adults; it requires no training to use and does not require changes in speech production that may result in unnatural sounding speech patterns. However, used in isolation, this method is not without drawbacks. First and foremost, a person who stutters is required to hear his or her own voice being fed back in order for altered auditory feedback to be effective. In the absence of audible speech production, the effects can be negated. That is, unlike true choral speech, where the second speaker is continuously present, AAF requires that some form of audible speech be produced so that the ameliorating condition can be put into effect. AAF used in isolation seems to be most effective with stuttering patterns that are predominantly comprised of voiced repetitions and prolongations. Those who experience long 'silent blocks', especially at the beginning of an utterance, may not derive maximum benefit from these isolated effects due to their failure to produce a speech source from which to derive the choral effect.

This drawback can be overcome by making intermittent use of 'vowel prolongation'. Vowels contain the most 'powerful' speech sounds and are perceived saliently through devices that produce AAF. Therefore, short vowel prolongations can be used to 'highlight' the speech signal. A short training protocol that lasts less than 3 h and teaches short vowel prolongations based on individual stuttering patterns has proven to be highly effective in reducing stuttering when used in conjunction with the use of ear-level AAF devices. Moreover, the intermittent use of short prolongations seems to be easily implemented without compromises to speech naturalness. This synergistic protocol can allow even those who exhibit silent stuttering blocks to derive higher levels of fluent speech than by using either AAF or prolonged speech methods in isolation. So far, this protocol seems to be withstanding the test of time, producing stuttering inhibition that is stable over the long term. It should be noted, that a fundamental difference exists between using this approach and previous methods that have combined AAF with operant procedures. Previous methods have used AAF only to help instill the prolonged speech pattern that formed the basis of speech retraining. The protocol described above makes use of the immediate inhibitory powers of choral speech, recognizing the fact that these inhibitory effects are best derived when a few vowels are highlighted, so as to optimally maintain the choral effect. To the best of our knowledge, the synergistic effects of a protocol that combines the inhibitory power of choral speech with the intermittent use of operant procedures to highlight the external signal, represents the best option for effective and efficient treatment of stuttering. Such a protocol seems to be effective with most stutterers, with many achieving over 70% immediate inhibition of overt stuttering symptoms.

The protocol described above has been effective in treating children and adults who stutter and may be the
first entry by the ‘digital paradigm’ into the milieu of stuttering therapy. Children as young as 7 years old have been fitted with such devices. Aside from the diagnosis of stuttering, the only criteria that users should meet are being able to hear and attend to the altered auditory feedback. As of now, 7 years seems to be the approximate age where these devices may be appropriate as a long term treatment option. However, this does preclude children younger than seven from being exposed to altered auditory feedback as a precursor for later long term management. In fact, the use of AAF has a distinct advantage over other forms of therapy in that it allows the opportunity for each individual to test it before considering it as a treatment option. With providers of ear-level devices in almost every state and international availability forthcoming, almost all potential candidates have the opportunity to test a device both inside and outside the confines of a clinical setting. The training periods are short and efficient (approximately 3 h), especially when compared to those typically seen in behavioral therapies. The potential for improvement can be assessed almost immediately, and the need for extensive continued visits to the therapist is rare. Furthermore, companies such as Casa Futura make larger, less portable, yet nonetheless powerful devices that provide AAF. These are cheaper than ear-level devices, and allow the effects to be presented through headphones. Many speech pathologists are in possession of such devices and can quickly screen potential candidates of any age for AAF use. Lastly, Artefact offers powerful AAF software that can be downloaded onto a personal computer so those considering AAF as an option for treating stuttering may test the effects in the comfort of those own home, simply via the use of a microphone and headset plugged into their computer.

Another potential drawback when using ear-level AAF outside of the clinic is the potential for interference from ambient noise. Although these devices have specific frequency outputs, that are generally preset to highlight vocalic speech frequencies and suppress outside noise-related frequencies, users often describe difficulties in environments such as noisy restaurants or work environments for adults, or cafeterias and playgrounds for children. However, most frequent users report that after a period of continued use, as their system adjusts to the device and they learn to ‘accommodate’ the altered speech signal, background noise ceases to be a salient concern. We expect future generations of such devices to be better equipped for dealing with noise-related concerns.

Finally, many speech therapists have been trained in behavioral therapies and probably spent years administering operant behavioral therapies. These therapists may be reluctant to consider the use of AAF in the treatment of stuttering. Many still view prosthetic devices as a crutch and stuttering a disorder that can be overcome with continued ‘practice’ and ‘dedication’ to the craft of fluency skills. They wonder whether the use of such devices will result in dependence over time. To those ends, we must simply refer to the WHO definition of stuttering, stressing that stuttering is an involuntary disorder and will continue to be so, regardless of the amount of training involved. If a prosthetic device helps to overcome stuttering symptoms, then it should not be considered a crutch. Do we consider people who wear glasses to overcome vision problems to be employing a crutch? The answer is a resounding ‘no’, and we suggest that a similar view be taken in the case of stuttering. In a similar vein, parents who simply wish the best for their children may opt for behavioral interventions before testing an ear-level prosthesis. However, we suggest that parents should be informed with regards to the involuntary nature of the disorder, the developmental course of the disorder, and the options available should traditional methods fail to bring about a suppression of stuttering symptoms in a timely fashion.

Conclusions

We believe that the use of altered auditory feedback and other derivations of choral speech will eventually lead to even more efficient and effective forms of stuttering management. Perhaps, this first generation of digital devices has only begun to scratch the surface in the digital age of stuttering inhibition. Yet, even at these early stages of development, they present a viable alternative to behavioral therapies. Perhaps, as our research draws us closer to the true source of stuttering, a pharmacological agent or genetic treatment may supplant digital paradigms in their efficiency and effectiveness. However, progress in these other fields has yet to yield any viable treatment for stuttering and their potentials may not be realized until well into the future. In the meantime, as with other disorders for which no cure exists, those afflicted should be aware of the true nature of their disorder and how it may impact their options for treatment.

References

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