

Critical Review:
Does Delayed Auditory Feedback Improve Speech Intelligibility in Parkinson's Disease?

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This critical review examines the effect of delayed auditory feedback (DAF) on speech intelligibility in Parkinson's disease. Each of the eight articles included in this review examines speech rate and intelligibility with the use of DAF in patients with Parkinson's disease. Three of the eight articles found positive effects on intelligibility with the use of DAF and five of the eight articles found negative or no effects on intelligibility while using DAF. The outcomes of these studies indicate mixed evidence for improvements in intelligibility in Parkinson's disease with the use of DAF.

Introduction

Many people with Parkinson's disease exhibit speech disturbances associated with hypokinetic dysarthria. This is the only type of dysarthria that includes the characteristic of increased speech rate. This rapid rate of speech is associated with reduced intelligibility in some people presenting with hypokinetic dysarthria.

There are many rate modification techniques, but several of these techniques, such as the use of a pacing board or hand tapping, place mental and physical demands on the patient. Furthermore, many of these techniques require extensive training in order to be used effectively. One option for modifying speech rate to improve intelligibility is the use of a delayed auditory feedback device. Delayed auditory feedback (DAF) allows the clinician to find the optimal delay setting for each patient and requires little training. These devices are small and portable and are becoming increasingly more available to the public. DAF may be an effective treatment option for improving speech intelligibility in people with Parkinson's disease.

Objectives

The key objective of this paper was to critically evaluate the existing literature to determine whether or not delayed auditory feedback is an effective treatment technique for improving intelligibility in people with Parkinson's disease.

Methods

Search Strategy

Computerized databases including SCOPUS, CINAHL and PubMed were searched using the following search strategy:
((Parkinson's disease) or (hypokinetic dysarthria) AND (delayed auditory feedback))
The search was limited to articles written in English.

Selection Criteria

Articles that were selected for inclusion in this critical review were required to use delayed auditory feedback as a treatment technique and measure intelligibility outcomes following treatment. There were no limits set on the demographics of research participants.

Data Collection

Results of the literature search generated the following types of articles matching the aforementioned selection criteria: mixed non-randomized clinical trial (2), between groups non-randomized clinical trial (1), case control (1), single group or case-series post test only (2), single group or case-series pre-post test (1), and single subject changing criterion multiple treatment design (1).

Results

Positive Impact of DAF on Intelligibility

In a study by Hanson and Metter (1983), two patients with Parkinson's disease used DAF over

a four-month period in an attempt to decrease speech rate. Both of these patients had rapid speech rates and reduced intelligibility prior to the study. Reading samples taken from the Grandfather Passage and a conversational speech sample were used to determine intelligibility and rate. A delay of 150 ms was used for both patients and resulted in a significant decrease in speech rate for reading and conversation. Intelligibility was significantly improved in conversation only for one patient and significantly improved in both reading and conversation samples for the second patient.

Wang, Metman and Bernard (2008) studied the effects of DAF in combination with frequency altered feedback (FAF) on nine patients with Parkinson's disease. Prior to treatment, these patients presented with moderate to severe speech impairments mainly characterized by palilalia and hesitations. As speech rate was measured on a three-point scale rather than words or syllables per minute, it was unclear of whether the pre-treatment speech rates were abnormally fast. Reading and controlled monologue were used to measure intelligibility under six conditions (two baseline, two placebo and two experimental). Optimal delay settings were determined for each patient (ranging between 50-220 ms) and frequency was shifted 500 Hz upward for each patient. The Unified Parkinson's Disease Rating Scale – III (UPDRS-III) was used as a perceptual measure of intelligibility. Results showed no significant improvements in intelligibility for reading during altered feedback conditions. There were, however, significant improvements in intelligibility during the monologue task in altered feedback conditions. Interestingly, speaking rates were perceived to be slower during the reading tasks and unchanged during the monologue tasks.

Rousseau and Watts (2002) included ten Parkinson's patients and five controls in their study on the effect of DAF on speech rate and articulatory response susceptibility. The group of patients with Parkinson's disease was divided equally into a high intelligibility group (HPD) (pre-treatment intelligibility score at or above 80%) and a low intelligibility group (LPD) (pre-

treatment intelligibility score below 80%). The Assessment of Intelligibility of Dysarthric Speech (AIDS) was used to measure intelligibility during delayed feedback. Delays of 50 ms and 150 ms were used for each participant. The LPD group showed significant improvements in intelligibility for both delay settings. On the other hand, the HPD group demonstrated decreases in intelligibility during both feedback delay conditions. Speech rates were reduced for all groups, with the LPD group demonstrating the greatest reduction.

Negative or No Impact of DAF on Intelligibility

Brendal, Lowit and Howell (2004) also used a divided group of Parkinson's patients consisting of LPD and HPD groups. Seven patients were included in the LPD group (one standard deviation below the control group intelligibility). Nine Parkinson's patients were included in the HPD group (patients that fell within the control group intelligibility range). Eleven control subjects were also included in the study. All but one of the patients with Parkinson's disease presented with moderate-severe dysarthria. Three conditions (no altered feedback, DAF and frequency shifted feedback) were used during reading tasks. A delay of 150 ms and an upward frequency shift of half an octave were used for each participant. Direct magnitude estimation was used to measure intelligibility. Speech rates were significantly reduced during DAF; however, there was a significant decrease in intelligibility scores for all groups. It is interesting to note that the speech rates for the HPD group were the same as the control group rates with no altered feedback. Furthermore, the LPD group speech rates were slower than the other two groups with no altered feedback.

Dagenais, Southwood and Lee (1998) looked at DAF in three patients with stage three Parkinson's disease. All three of the patients presented with hypokinetic dysarthria and demonstrated a rapid rate of speech prior to treatment. The AIDS was used to assess pre- and post-treatment intelligibility measures. Each patient underwent different procedures, which were mainly determined based on the other

patients' performances with DAF. They found a large variability in intelligibility and speech rate while using DAF for all three patients. Speaking rates were not significantly reduced or consistent and there were minimal changes in intelligibility when DAF was used alone.

Dagenais, Southwood and Mallonee (1999) included ten patients with Parkinson's disease, ten age and gender-matched controls and ten gender-matched young adults in their study. The patients with Parkinson's disease demonstrated various speech impairments, including none, prior to treatment. Delays of 125 ms and 231 ms were used in reading, picture description and spontaneous speech tasks. Intelligibility scores in the Parkinson's group decreased slightly during both feedback delays on all three tasks. During reading and spontaneous speech tasks with no delayed feedback, the Parkinson's group had the same speech rate as the age-matched control group and a slower rate than the young adult group. During the picture description task with no delay, the Parkinson's group had slower speech rates than the other two groups.

In 1981, Downie, Low and Lindsay looked at the effect of DAF on eleven patients with Parkinson's disease. No methods or measures were reported and only two cases were described in this article. For one of these patients, DAF improved intelligibility as a result of reduced rate of speech using a 50 ms delay but the patient habituated to the device after one year. The second patient demonstrated a good response to DAF with a delay of 50 ms and the patient had not habituated to the device after two years. DAF was not found to be effective for the other nine patients.

Van Nuffelen, De Bodt, Wuyts and Van De Heyning (2009) studied the effects of seven rate modification techniques on nineteen patients with various types of dysarthria. There were five patients included in the study with Parkinson's disease and hypokinetic dysarthria. Three delayed feedback settings were included in the study (50 ms, 100 ms and 150 ms delays). Only one of these five patients demonstrated an improvement of 1-10% for intelligibility using DAF.

A review of the statistical analysis used in each study revealed that the majority of the studies used one, two or three-way ANOVA's and/or T-tests appropriately. (Dagenais, Southwood & Lee, 1998; Dagenais, Southwood & Mallonee, 1999; Hanson & Metter, 1983; Rousseau & Watts, 2002, Wang, Metman & Bernard, 2008). Brendel, Lowit and Howell (2004) used two non-parametric tests: the Wilcoxon and the Mann-Whitney-U-Test. Van Nuffelen, De Bodt, Wuyts and Van De Heyning (2009) used pairwise comparisons of estimated marginal means due to the nature of their study. Finally, Downie, Low and Lindsay (1981) did not report any statistical analysis.

Discussion

The findings from these studies show that the evidence for the use of DAF to improve intelligibility in Parkinson's disease is inconclusive. There are many possible factors contributing to these findings and as such, further research needs to be conducted in this area. For example, the studies that showed a positive effect on intelligibility included patients with mild to poor intelligibility or moderate to severe speech impairments prior to the studies (Hanson & Metter, 1983; Wang, Metman & Bernard, 2008). On the other hand, the studies that did not show improvement in intelligibility with DAF included patients with varying degrees of speech impairments and pre-treatment intelligibility scores of 70% or higher (Dagenais, Southwood & Lee, 1998; Dagenais, Southwood & Mallonee, 1999; Downie, Low & Lindsay, 1981; Van Nuffelen, De Bodt, Wuyts & Van De Heyning, 2009).

Interestingly, the two studies that divided the Parkinson's patients into high and low intelligibility groups demonstrated conflicting results. Rousseau and Watts (2002) found that the low intelligibility group showed improvements in intelligibility with DAF whereas the high intelligibility group demonstrated decreases in intelligibility. Brendel, Lowit & Howell (2004) reported decreases in intelligibility with DAF across all of the groups. This indicates a need for further

research using patients with varying degrees of pre-treatment intelligibility.

Another factor that could have affected the results in many of these studies is the pre-treatment rate of speech of the patients. Since DAF is often used to decrease speech rate in an attempt to improve intelligibility, using DAF on patients with normal or decreased rates of speech may have negative effects on intelligibility. Hanson and Metter (1983) used patients with rapid speaking rates prior to treatment and found that DAF improved intelligibility. The other studies either did not measure speaking rate prior to treatment or the patients had similar or slower speaking rates compared to the control groups. Therefore, it is possible that patients with rapid rates of speech may show greater improvements in intelligibility with the use of DAF; though this needs to be addressed specifically in future research.

The amount of delay used for each patient and the methods used to measure intelligibility are two additional factors that could also have an effect on the overall findings. As can be seen in the results section, six of the eight studies included in this critical review used the same delay across patients rather than determining the optimal delay for each patient. Each person responds to varying lengths of delays differently and if the most advantageous delays for each patient were used, the results may have changed. Additionally, many different methods were used to measure intelligibility across these studies. For example, the Assessment of Intelligibility of Dysarthric Speech (AIDS), reading passages; the UPDRS-III and direct magnitude estimation were used within various studies to measure intelligibility with and without the use of DAF in the Parkinson's patients. This makes it difficult to compare studies that have used differing methods to measure intelligibility.

Recommendations

The results from these studies illustrate that DAF may not be a useful tool to improve intelligibility in all people with Parkinson's disease. There may be factors contributing to the effect of DAF on individual patients that need to

be studied explicitly. For example, one's habitual speech rate prior to treatment may have an effect as DAF decreases speech rate in most people. Also, the intelligibility score prior to treatment may also have an effect and should be studied further.

Clinical Implications

This critical review of the literature available indicates that DAF may not be beneficial in improving intelligibility across all people with Parkinson's disease. Due to this, it is important that the clinician evaluate each patient's response to DAF independently to determine whether or not it is beneficial. There are some patterns in the current research that may indicate better candidates for DAF. For example, a patient whose pre-treatment intelligibility is below 80% and whose speech rate is fast may have a greater chance of improving intelligibility using DAF. This still needs to be verified by future research, however.

Until additional research is conducted, the clinician must be aware of the mixed evidence for the use of DAF to improve intelligibility in patients with Parkinson's disease. This is why it is important that the clinician conduct a trial period for each patient that may be a candidate for the use of DAF to improve intelligibility.

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