

Critical Review:

What are the effects of variable feedback frequency on the retention of speech motor skills?

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In practicing and learning a new skill, feedback may be provided to an individual regarding performance. During intervention of impaired speech motor skills, Speech Language Pathologists often provide some form of immediate feedback following each trial giving knowledge of results. This critical review explores the research available on the effects of variable feedback frequencies on the retention of speech motor skills. The three studies being reviews were carried out with normal subjects, individuals with Parkinson's disease and individuals with acquired apraxia of speech (AOS). Each study attempts to determine whether reduced feedback frequency will improve retention of speech motor skills, as this has already been hypothesized from studies of nonspeech motor skills (limb studies). Maintenance of skills is a fundamental part of speech therapy and the success of intervention programs. Research results could have significant implications on how feedback during therapy is conducted. If reduced frequency feedback was found to improve retention of speech motor skills, implementation into intervention programs could be made without any additional cost or training. Each study states that more research is necessary in this area; however, preliminary evidence suggests promising results of reduced frequency of feedback improving retention in speech motor learning.

Introduction

Motor speech disorders (MSDs) occur when an individual is not able to speak properly as the coordination, timing, or strength required to speak is affected. As defined by Duffy (2005), "motor speech disorders result from neurologic impairments affecting the motor planning, programming, neuromuscular control or execution of speech". Both acquired and developmental forms of dysarthria and AOS comprise MSDs. Dysarthria is a result of disruption or disorder of muscular control and AOS is considered a disruption in the planning or programming of speech (Duffy 2005).

Treatment of MSDs focuses on behavioural treatment and involves principles of motor learning because production of speech is a motor skill. Treatments are aimed to establish new, or reorganize/reestablish old motor sequences (Maas et. al. 2008). Motor skill learning is influenced by a number of principles that have an effect on acquisition, transfer, and retention. These include the structure of practice stimulus selection (ex. blocked versus random practice, single versus multiple task), and the nature of feedback (ex. high versus low frequency, varying knowledge of results) (Adams and Page 2000). Evidence from nonspeech motor learning indicates that the manipulation of the principles of motor learning may improve the retention of skills. Current information known for nonspeech motor learning is established, yet there have been few studies that have examined motor

learning principles such as variable feedback frequencies on speech motor learning. Available evidence of frequent versus reduced frequency feedback provides promise for the retention of speech motor skills in normal subjects and subjects with Parkinson's Disease (Adams and Page 2000, Adams, Page and Jog, 2002) and AOS (Austermann et. al. 2008). However, further research is necessary to better understand the full effects of variable feedback frequency on speech motor learning.

Feedback following clinical interventions is a component of all treatment programs and therefore, it is important to consider in the clinical decisions regarding intervention of individuals with MSDs. Adjusting the feedback frequency during therapy treatments is an applicable change to any intervention method and does not require additional training or cost. This simple variation to therapy provided by speech language pathologists could have significant clinical implications to the retention of speech motor learning for individuals with MSDs.

Objectives

The primary objective of this paper is to provide a clinical review of the existing literature which examines the principles of motor learning and the possible implications on speech motor learning. Specifically, variable feedback frequency will be evaluated in order to provide current information and effects that delayed

frequency feedback can have on the retention of speech motor skills.

Methods

Search Strategy

Computerized internet databases were searched including Pubmed, CINAHL Google Book Search, and Google Scholar. The following key terms were used ((variable feedback frequency) or (speech motor learning) and ((motor speech disorders) or (dysarthria) or (AOS) or (apraxia of speech)).

Selection Criteria

Studies selected for evaluation for this clinical review were required to study the effects of variable frequency on therapy outcomes, specifically relating to the retention of speech motor skills. Papers were inclusive to all populations and were not limited to any specific demographics due to the limited available evidence in this area.

Data Collection

The data search yielded one paper that fit the aforementioned search criteria which studied speech motor learning in 6 adults with AOS in a single subject treatment design. Two additional papers were located using the references of the articles found through the database search. One studied speech motor learning in normal subjects with the other studying individuals with Parkinson's disease.

Results

Two types of study designs were used to evaluate the results of variable feedback frequencies on the retention outcomes of speech motor skills in individuals with MSDs. Described below are between group, non-randomized control trials (2) and an alternating treatment single-subject design involving 4 participants.

Non-Randomized Control Trials

Randomized control trials were not available for review in this area. The two studies described below are between group, non-randomized studies which provide level 2 evidence.

Using a convenience sampling method, Adams and Page (2000) selected and studied forty healthy young female subjects (aged 21 through 41 years). The women were observed while learning a speech motor task (reduced speech rate) under three practice and feedback variables. The women were randomized into groups of 10 and results were compared between groups.

Two groups of 10 were made to evaluate the effects of variable (high versus low) feedback frequencies. One group received feedback following each trial (high frequency), while the other received feedback after every five trials (low frequency). The participants practiced repeating the phrase "buy Bobby a poppy" in a 2400 millisecond time frame. This is approximately two times slower than a normal speech rate. The remaining groups studied two other practice variables, blocked vs. random practice and single vs. multiple task practice. The groups created to observe effects of variable feedback frequencies received knowledge of results feedback from a graph paper display following every one or five trials. The subjects wore a head set with a microphone that recorded responses and displayed it on a screen (visible only to the examiner). The examiner then calculated the rate and plotted it on the graph paper set in front of the subject.

During the acquisition phase, subjects produced fifty practice trials while receiving feedback after every one or five trials. Subjects also participated in a 20-trial retention test conducted two days following practice trials without receiving feedback of the results. In order to measure performance accuracy and estimate motor acquisition and retention an absolute error value between the targeted and actual response duration was calculated. The acquisition and retention scores were estimated by obtaining an average of the last 5 trials of each phase. To observe the difference between the two groups, t-tests ($p < .05$) were used.

The study found the retention scores of the group receiving feedback following five trials were significantly better than those receiving feedback after every trial ($p < .05$). This implicates the use of lower frequency feedback for improved learning and retention of speech motor skills in normal subjects.

A similar study conducted by Adams, Page and Jog (2002) examined the same speech motor learning task in individuals with idiopathic Parkinson's disease. Through a convenience sampling method, eighteen subjects were selected to participate in the study. Participant's speech and limb symptoms varied from mild to moderate. Ages ranged from 48 to 70 years and included 4 women and 14 men. Each subject was on a regular schedule of Levadopa medication and had taken the medication 1-2 hours prior to their participation in the study.

Participants were randomly assigned to two groups (9 members in each). One group received feedback following each trial and the other received feedback after every fifth trial. Similar to the study above, participants were asked to produce the phrase "buy

Bobby a poppy” in a 2400 millisecond time frame. A practice block of fifty trials was conducted with a 20-trial retention test taken after ten minutes and again after two days. Absolute error values between the targeted and actual response duration were calculated as they were in the normal subjects. T-tests ($p < .05$) were used to examine differences between the groups in their average ten minute and 2-day retention absolute error scores.

Results for the ten minute retention phase failed to show significant difference between groups receiving feedback following each trial or every 5 trials ($p < .05$). The group receiving feedback every 5 trials produced significantly lower error scores during the 2-day retention phase ($p < .05$). Similar to the Adams and Page (2000) study with normal participants, the results of this study support the use of reduced frequency feedback for individuals with Parkinson’s disease to improve retention of speech motor skills.

Single Subject

Austermann et. al. (2008) conducted a single-subject alternating treatment study involving subjects with acquired AOS. This examined effects of feedback frequency and timing on the acquisition, retention and transfer of speech motor skills. For the purpose of this paper, results of the feedback frequency on the retention of skills will be discussed more closely. This single-subject design provides level 1 evidence

Four participants (3 men and 1 woman; $M=70.3$ years of age, $SD = 3$ years) with AOS (mean time onset = 13.3 months; range 6-20 months; $SD = 5.9$ months) were involved in the study, each having experienced a left-hemisphere middle cerebral artery stroke. Participants were selected using a convenience sampling method. Formal testing of each participant was conducted 2 weeks prior to the study using the *Boston Diagnostic Aphasia Examination Battery* (BDAE; Goodglass, Kaplan, and Barresi, 2001) with results showing a wide variety of severity of impairments across participants. During treatment, an alternating treatment design was used. Related but untrained behaviours were probed throughout therapy to assess transfer of trained behaviours. Goals of intervention were unique to each participant and depended on their level of severity and stimulability. Each treatment phase was four weeks in length with approximately four treatment sessions per week. A four week maintenance period was also conducted following the therapy phase, but was dependent on participant availability. Long term retention data after eight months was collected for participant one and four only. Increased retention of the speech targets trained under

low frequency conditions was found in two of the four participants. No statistical evidence was conducted to accompany the described results of each participant involved in the study. Reduced frequency feedback revealed mixed results in each of the participants with AOS with two of four participants showing improvement in retention of all skills provided with low frequency feedback.

Discussion

The results of the studies exploring speech motor learning in normal subjects and those with Parkinson’s disease suggests that reduced frequency feedback use in intervention programs may have positive results on retention of skills. However, the results found in subjects with AOS were inconsistent. In order to determine the strength of the evidence provided by these studies, it is important to look closely at the methodological strengths and limitations of each.

Studies with normal subjects conducted by Adams and Page (2000) provide positive evidence of lower frequency feedback improving the retention of speech motor skills. However, methods of sampling may reduce the efficacy of the study. Because of the small sample size and lack of demographically diverse participants, it is difficult to conclude that these results represent the normal population. Subjects did not include male subjects and were all aged between 24 and 41. Therefore it is difficult to generalize these results to an older population.

A second weakness of the study lies in the methodology. It has been found in nonspeech motor studies that feedback varying in terms amount of knowledge of results provided, delay of provision and frequency can all effect retention of skills. Limb studies conducted with immediate and delayed feedback found that delayed feedback had positive effects on retention of nonspeech motor skills (Maas 2008). In the study conducted by Adams and Page (2000), the examiner first had to calculate the rate presented on their visual display before feedback could be provided, therefore creating a delay or variations in the timing of feedback that was not clearly reported. This method of calculating the correctness of responses makes it difficult to determine if findings were a result of low frequency feedback or variable delay in the feedback provided. However, as this variable was consistent throughout both groups (high and low frequency), it can be assumed that improvements in retention were likely due to the low frequency of feedback.

With the exception of these two weaknesses, statistical evidence and general methods of the study appear

sound. The study does suggest positive implications for altering the provision of feedback to improve retention of speech motor skills in normal subjects. Conclusions should still be made with caution. Additional research is needed to determine whether the feedback variables would be beneficial for individuals with motor speech disorders or in learning other speech parameters. Also, further research is needed to examine long term retention as retention data only explores results two days following treatment.

Consistent with the findings of speech motor learning in normal subjects by Adams and Page (2000), Adams, Page and Jog (2002) observed improved retention of speech motor skills in Parkinson's disease. Since both studies had similar methodology, the study had similar limitations as described above in concluding whether results are due to the low frequency feedback or delay in feedback. Also, speech symptoms of the Parkinson's patients ranged from mild to moderate, therefore results cannot be generalized to those with severe symptoms.

Similar to the study conducted by Adams & Page (2000), further long-term retention results are open to further research as only short term retention data was done. Further research is also required to explore effects of low frequency feedback on other dysarthria types.

Austermann et. al (2008) studied participants with AOS and found support for individuals benefiting from low frequency feedback. They also concluded that further research needs to be done regarding factors such as task difficulty. The alternating treatments design made it possible to separate the effects of the experimental treatment variables from potential spontaneous recovery. The protocols used to conduct the study, however, cause reason for caution. Each individual participating in the study had unique goals and therefore control of variables and conditions across participants was not possible. Furthermore, since each goal selection was individualized, improvements in the targeted skills could have been effected by the level of difficulty of the skill. Similarly, past performance and level of severity were not considered in discussion of results. A further limitation lies in the lack of statistical evidence for comparison of results either within or across participants.

Methods of scoring targeted goals may have also affected the results found by Austermann et. al. (2008). Target goals were scored subjectively online by a trained examiner leaving room for possible errors in judgment. Between participants and between speech skills, improvements were seen both with the low frequency and high frequency treatment conditions.

Therefore it is difficult for true comparisons of each treatment method to be made. In addition, because of the small sample size, results also cannot be easily generalized to other individuals with AOS or other individuals with MSDs.

Conclusion & Recommendations

Current research in the principles of motor learning has primarily been focused on nonspeech motor or limb motor tasks. In addition, research of nonspeech motor learning of disordered individuals is limited. But of studies conducted, evidence suggests improved treatment and retention outcomes when principles of motor learning, such as feedback frequency, are incorporated into intervention practices. Similarly, studies conducted with speech motor tasks on both normal and disordered individuals also hold promise for improved retention of skills following intervention programs with low frequency feedback parameters. However, because of the limited research in this area, it is recommended that further studies be conducted to determine if the retention outcomes of all MSDs can benefit and to what degree. Similarly it would be important to determine the frequency of feedback that is most advantageous, and if this varies depending on the disorder area, skill difficulty level or type of speech parameter or motor skill (i.e. loudness, articulation, prosody) being targeted. Further research is also needed to observe the effects on long term retention.

Although variable feedback frequency was discussed primarily throughout this paper, it is beneficial to note that other principles of motor learning have also been found to increase the retention of motor skills. For example, knowledge of results of the feedback provided, immediate or delayed presentation of feedback, blocked versus random practice, and single versus multiple task practice. Further research is also needed in these areas to examine the possible effects of combining these principles in intervention programs.

Clinical Implications

The results of these studies indicate potential for intervention procedures treating MSDs to have improved retention results with the use of motor learning principles such as reduced frequency feedback. Implementing reduced frequency of feedback into an intervention program could be done without cost or additional training. Therefore, further understanding and exploration of the effects of the principles of motor learning could prove to be valuable to speech language pathologists in behavioural treatments of MSD. These initial results hopefully motivate clinicians to conduct further research in this area as research is still

extremely limited in this area. Further studies are required to explore the effects of reduced frequency on treatment outcomes in individuals with differing motor speech disorders and speech parameter targets.

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