A critical review of the effect of singing on intelligibility and other speech characteristics in adults with dysarthria

Veronica Saunders
M.Cl.Sc (SLP) Candidate
University of Western Ontario: School of Communication Sciences and Disorders

This critical review examines the effect of singing on speech characteristics of adults who have dysarthria. Study designs include: two case studies, a single system design with baseline reversal, a multiple case study experimental design, and an informational article. Overall, research suggests that singing may improve speech characteristics and intelligibility of adults with dysarthria. The conclusions of this critical review should be considered with caution due to the small number of subjects that were examined across the four studies (n=9). Clinical and future recommendations are discussed.

Introduction

Dysarthria is a collective name for a group of motor speech disorders that are a result of abnormalities in strength, speed, range, steadiness, tone or accuracy of movements that are required to control aspects of speech production such as respiration, phonation, resonation, articulation, and prosody. (Duffy, 2005). According to Duffy (2005), the underlying neuropathophysiological disturbances are due to abnormalities in the central or peripheral nervous system. These disturbances may result in decreased strength, an increase in spasticity, incoordination, involuntary movements or excessive, reduced or variable muscle tone, resulting in the abnormalities in speech production that are characteristic of dysarthria (Duffy, 2005). There are 7 types of dysarthria, each with their own prominent speech characteristics (Darley, Aronson & Brown, 1969). In addition, it is presumed that each of these types of dysarthria are also as a result of a different underlying neuropathophysiology (Duffy, 2005). There is some evidence to support that at least in the case of hypokinetic dysarthria the signs of dysarthria vary across speech tasks (Kempler & Van Lancker, 2002).

According to Tamplin and Grocke (2008), there are a small, yet increasing number of publications on the use of music therapy in neurorehabilitation. Music therapy, as defined by Magee, Brumfitt, Freeman and Davidson (2006), is the planned and intentional use of music to meet an individual's needs and specified client-centered goals within a therapeutic relationship. There is evidence to support the use of music therapy as an effective treatment with individuals who have communication impairments resulting from brain injury or other neurological trauma (see Magee, Brumfitt, Freeman & Davidson, 2006). Specifically, individual's presenting with expressive aphasia have benefited from Melodic Intonation Therapy (MIT) or modified MIT with regards to increasing their verbal intelligibility, and their language production (Magee, Brumfitt, Freeman & Davidson, 2006). Kempler and Van Lancker (2002) report that clinical observations suggest, patients with hypokinetic dysarthria are more intelligible when singing than when speaking.

Objectives

The primary objective of this paper is to critically evaluate the existing literature pertaining to the impact that singing has on the speech of adults who have dysarthria.

Methods

Search Strategy

Computerized databases, including CINAHL, Web of Science, ProQuest Nursing Journals, and PubMed were searched using the following search strategy: music therapy AND speech; music AND dysarthria; music therapy AND dysarthria; singing AND speech; singing AND dysarthria. The search was limited to articles written in English.

Selection Criteria

Studies selected for inclusion in this critical review paper were required to investigate the impact of singing on speech characteristics in adults with dysarthria.

Data Collection

Results of the literature search yielded the following types of articles congruent with the aforementioned selection criteria: two case studies, one single system design with baseline reversal, one multiple case study experimental design, and one informational article.

Results

Kempler and Van Lancker (2002) investigated the intelligibility of a 74 year old male who was a retired professor, native English speaker and who had

dysarthric speech secondary to Parkinson's disease (18 years post-onset), across five speech tasks (spontaneous speech, repetition, reading, repeated singing and spontaneous singing). He was stage 2 on the Hoehn and Yahr (1976) rating scale for Parkinson's disease. Speech impairment was one of his primary symptoms. The Assessment of Intelligibility of Dysarthric Speech was used to measure his intelligibility, and this revealed that he was 46% intelligible for single words, 68% intelligible for sentences and had a speaking rate of 137.5 words per minutes, resulting in an efficiency ratio of 0.49. The researchers obtained vocal production samples (ie. one researcher had a conversation with the participant regarding his early life, while the other researcher transcribed 30 consecutive utterances) from the participant for later comparison of intelligibility to the five different production tasks. These 30 utterances were transcribed legibly in large print on to three sheets of paper, each sheet containing 10 utterances, numbered 1-10. These were presented to the participant to elicit production in three other speech tasks: reading, repetition and repeated singing (the order of these tasks was counterbalanced for each sheet of utterances). In a separate session, several weeks after the first session, spontaneous singing was elicited. From the original 30 utterances (each elicited in four speech tasks) and an additional 8 utterances from the spontaneous singing condition, a set of 136 stimuli (semantically coherent phrases) was selected to make four listening tapes. Each tape included a different speech task version of each of the utterances. Sixty-four subjects listened to 4 practice items (with immediate feedback given) and 40 test items, and transcribed portions of each stimulus onto blank lines on an answer sheet.

To determine intelligibility of utterances in the five conditions, correctly transcribed words were counted. Singular/plural listening errors were counted as correct (e.g. 'cat' for 'cats'). Comparisons were made between the five speech tasks and the number of correct words on the four tapes. No difference in overall level of difficulty was revealed ($F(3,156)<1$), and therefore the data from the four tapes was combined for the subsequent analyses. Overall, listeners correctly transcribed 29% of the spontaneous speech, 78% of the reading utterances, 79% of the repeated speech, 80% of the repeated singing, and 88% of the spontaneously sung utterances. A within-subjects design, one-way Analysis of Variance (ANOVA) examining speech task with intelligibility was highly significant ($F(4,155)=33.62$, $p=.0001$). Post hoc t-test comparisons revealed spontaneous speech was significantly different from each other task ($p<.05$), and the other four tasks were not significantly different from one another. Four analyses explored the relationship between intelligibility and the acoustic characteristics of the stimuli: relative intensity, word duration, dysfluency, and acoustic qualities as seen in spectrograms. For loudness, a significant effect of task was found ($F(4,131)=2.99$, $p=.02$). Post hoc comparisons revealed that spontaneous singing was louder than the other tasks ($p<.05$). Loudness was not correlated with intelligibility across all items ($r-.14$, $p>.05$), or across items within any of the speech tasks individually, suggesting other variables were also affecting intelligibility. Word duration was not significant ($F(3,124)=2.58$; $p=.057$), nor did it correlate with intelligibility ($r=.035$, $p=.66$). There was a significantly higher number (68%) of dysfluencies in the spontaneous items than in the other speech tasks ($X^2(4)=36.7$, $p<.001$). Lastly, using a rating system similar to that developed to characterize hoarseness by Yanagihara (1967a, 1967b), a qualitative measure of spectrograms was undertaken to determine whether there were acoustic differences between the speech tasks. The spontaneous speech task earned the poorest ranking. The spectrograms rated as good were most often associated with singing, then reading, then repetition. A Pearson's correlational analysis compared spectrographic rankings with intelligibility. This was significant ($r=-.41$, $p=.0001$), indicating better rankings were associated with greater intelligibility.

A limitation of the Kempler and Van Lancker (2002) study is the small sample size. This greatly limits the ability to generalize these results to other adults with dysarthria. Despite this limitation, this study does have a number of strengths. The researchers provide a detailed description of the participant, and their methods, therefore this study could be replicated. In addition, they include 64 listeners, therefore, despite the fact they have only one participant, they are still able to statistically analyze their data.

Tamplin (2008) conducted a pilot study, using a multiple case study design, to investigate the effects of vocal exercises and singing on the speech of 4 adults who had mild to severe dysarthria secondary to a neurologic damage (traumatic brain injury or stroke). Each participant received 24 individual music therapy sessions (three per week for eight weeks) that were 30 minutes in duration. These sessions consisted of vocal exercises and singing three familiar songs. Participants were encouraged to incorporate strategies taught in the vocal exercises into their singing. Feedback, encouragement, prompting and modeling were employed to assist participants to achieve maximum intelligibility and naturalness when singing. Intelligibility scores, speech rate and communication efficiency ratios were obtained using the Sentence Intelligibility Test. Five assessment measures were used in this study. Intelligibility, rate of speech, and communication efficiency ratio were measured using

the Sentence Intelligibility Test (SIT) and a Picture Description Task (PDT). In addition, speech naturalness was rated (by 15 speech pathologists and 15 non speech pathologists, using six naturalness categories), and waveform analysis was conducted.

The results for each outcome variable on the SIT and PDT were pooled together. ANOVAs with subject and stage of intervention as factors showed a statistically significant improvement of 6.75% in speech intelligibility on the PDT task between pre and post assessments and pre and mid assessments ($P<0.05\sim0.023$). Trends towards improvements were found for all other assessment measures, however, these results did not reach statistical significance. With regards to speech naturalness, 85% of the time, post-treatment sentences were rated more natural than pre-treatment sentences. To determine if this figure differed from chance, a one sample (2-sided) t-test was used, and revealed a statistically significant result. In addition, speech pathologists and not speech pathologist raters differed significantly, as determined by a one sample (2-sided) t-test ($P=0.04$). Lastly, there was an overall decrease in the use of pauses, and an overall decrease in the length of individual pause time across all subjects from pre to post assessment.

One limitation of the Tamplin (2008) study is the small number of subjects included. The authors state that with more subjects, their results that were reaching significance "may have resulted in the detection of significant difference between stages in all areas". Another limitation of this study is that the exercises that were used were not explained in detail, making this study difficult to replicate. In addition, there is a chance that the authors have introduced the possibility of a practice effect, as they use the same three sentences in each assessment session. However, these sessions occurred only three time, four weeks apart, so this effect was hopefully minimal. Lastly, with regards to clinical relevance, this study uses three sessions per week, which brings into question whether this would be practical in most clinical settings. Some strengths of this study include: the fact that participants were recruited based on criteria specified prior to the beginning of the study, the researchers used pre, mid and post assessments using the SIT and PDT for comparisons to measure improvements, and to reduce bias of the speech pathologist raters, they included a matched group of non speech pathologist raters.

Pilon, McIntosh and Thaut (1998) explored the use of auditory versus visual speech timing cues as external rate control techniques to enhance speech intelligibility in three adults who had mild to severe mixed spastic-ataxic dysarthria secondary to traumatic brain injury. Each participant participated in one session per week for a total of 6 weeks. In each condition (no pacing (NP), singing pacing (SP), metronomic pacing (MP) and board pacing (BP)) verbal intelligibility and speech rate were calculated. Speech samples consisted of 180 functional sentences for each participant (30 sentences for each of the six conditions). In the NP condition, the participants read a set of 30 sentences (different for each baseline measure). During SP, the researcher sang the melody at a tempo of 20% slower than the participants' baseline speech rate. Melody, tempo, stress and intonation patterns were closely related to what would be expected in spontaneous speech (e.g. rising intonation at the end of a question). In the MP condition, participants were instructed to read each sentence with an accompanying metronomic cue (set at 20% below the participants' baseline speaking rate). During the BP condition, participants were presented with one sentence at a time on a pacing board (one word per space). To familiarize the participants with the pacing boards, they were given verbal instructions, examples, and the opportunity to practice with a sentence that was not included in the testing. Results indicated that all three pacing conditions yielded higher intelligibility (SP 74% intelligibility, MP 80%, and PB 75%) than the baseline condition (NP 66%). A repeated measures Analysis of Variance (ANOVA) with planned comparisons between treatment conditions for pooled subjects indicated there was a difference approaching statistical significance ($F=4.81$; $p=0.053$) between baseline and the three pacing conditions combined. Differences between the three conditions were not statistically significant. Within subject ANOVAs for each participant showed a significant difference between the treatment conditions and the baseline for participant 1 ($F=5.9$; $p=0.001$) and 3 ($F=9.24$; $p=0.001$), but no difference for participant 2. Evidence of effective speech rate modulations in these participants was also noted. In all conditions, speaking rate decreased. For participants 1 and 3, there was an inverse relationship between intelligibility and speech rate observed, however, participant 2 showed the opposite trend. Pearson Production Moment correlation analysis was used to statistically analyze the relationship between intelligibility and words per minute. This analysis indicated that the inverse relationship noted for participants 1 and 3 was significantly correlated (participant 1: $r= -0.672$; $p<0.05$, participant 3: $r=0.91$; $p<0.05$). For participant 2, intelligibility and speech rate were positively correlated without reaching statistical significance ($r=0.52$; $p>0.05$).

Overall, this study was well done. One limitation of the Pilon, McIntosh and Thaut (1998) study is that they only had three participants (all males), making it

difficult to generalize the results to other adults with dysarthria. Despite this limitation, the participants represented a range of mild to severe dysarthria, all were diagnosed with primarily spastic-ataxic dysarthria, had similar etiologies (TBI) and had a similar length of time post injury (12 to 24 months). With regards to the methods, the procedure was fairly well described, ensuring that it could be replicated, and the researchers counterbalanced the presentation of the three treatment conditions across subjects, alternating with baseline. In addition, the panel of 18 judges who were unfamiliar with the sentences and had no prior knowledge of the characteristics of dysarthric speech listened to the recorded sentence samples, made it possible for the researchers to statistically analyze the obtained data.

Magee, Brumfitt, Freeman, and Davidson (2006), use a single case design to investigate whether music therapy helped to improve the communication and well-being measures of an adult male with dysarthria secondary to pseudobulbar palsy and a series of strokes. This participant's speech and behavioural symptoms are reflective of his diagnosis and are characterized by a slow, effortful speech rate, imprecise consonants, hypernasality, short phrases, strained and harsh voice, and limited pitch movement. An assessment of his perceptual speech behaviours was completed, using the Frenchay Dysarthria Assessment, revealing a moderate to severe level of impairment in all components of the motor speech system. His verbal intelligibility was assessed using the Assessment of intelligibility of dysarthric speech (ASSIDS). The results of this assessment indicate that he is 50% intelligible for single words, and 29% intelligible for sentences. His fundamental frequency range during speech exercises was 100Hz to 266Hz, with his mean fundamental frequency at 180Hz, which is higher than normal for males in his age range (70 years and over = 136.2Hz). The researchers hypothesized that the physical activity of singing may help to strengthen the participant's respiratory and phonatory movement patterns, resulting in an effect on his patterns of motor function for speech. A music therapist assessed the participant, one week prior to data collection to obtain baseline measures of his communication responses within musical activities (e.g. range of pitch, phonation, number of syllables sung on one exhalation, and voice quality) and his ability to engage and participate in therapy. A treatment protocol was planned based only on parameters of communication that showed the greatest change with music therapy in the baseline assessment. Exercises included: promoting physical relaxation; breath control; vocal activities on a range of sounds which targeted phonation and articulation; and pitch variation through singing exercises and simple songs. A total of six treatment sessions were provided in the participants home, 3 per week over a two week period. Results indicated: an improvement in duration of voiced exhalations; inconsistent improvements in range of pitch; an improvement in total pitch range; a strong movement towards a lower speaking fundamental frequency, and a similar trend towards a deeper voice in singing. In addition, data from Time 1 showed some evidence of improved voice quality, and vocal control during spontaneous speech. Data from Time 2 indicated a wider pitch range (100-212Hz) which was more typical of the norms for his age group. Furthermore, qualitative observations by the speech-language pathologist revealed that the participant was more spontaneous with less of a delay in his production when producing the musical stimuli, suggesting that the participant was becoming increasingly more aware of his own sound production. In addition, positive changes were also seen in all of the participant's well-being measures. The authors state that these results may have occurred by chance, as they were reported purely qualitatively, without statistical support.

In addition to the well-being measures being reported qualitatively, with no statistical analysis as support, a limitation of this study by Magee et al. (2006) is the fact they used a single subject design with an individual who has a complicated combination of problems, making it difficult to generalize the results. The authors state that "a different client…may have provided us with 'better', that is, more successful outcomes" (Magee et al., 2006). With regards to the procedure, the authors are not specific when discussing their tasks, therefore making this study difficult to replicate precisely.

In addition, with regards to clinical relevance, this study employs a therapy schedule of three times a week, which may not be practical in many therapy settings. Also, the authors selectively chose to take data only from the beginning of the session to evaluate, due to fatigue occurring by the end of the session. This data may not have been representative of this individuals abilities as the authors state that "perseveration..appeared to inhibit his ability to sing both upward and downward melodic contours in the initial activity" and "prosodic responses were noted to worsen within the course of each session, in particular pitch range achieve". Lastly, the authors support that with the above limitations it is difficult to draw precise conclusions. Despite the number of limitations presented here, the authors provide a detailed description of the participant, and use objective measures, meaning that although we are unable to generalize the results to other adults with dysarthria, we have the profile of an individual that may benefit from this treatment.

Discussion

Based on the studies gathered and reviewed above, it is evident that more evidence-based research is required on the topic of using singing to improve speech characteristics and intelligibility in adults with dysarthria. Of the four articles reviewed in this paper, all were found to have relatively weak levels of evidence, due to the low number of participants. However, there is a trend showing that singing may increase intelligibility and improve certain speech characteristics associated with dysarthric speech in adults.

There are a number of factors to consider when assessing whether singing improves intelligibility or speech characteristics. For example, breath support, speaking volume or rate of speech may actually account for the improvements. In the Kempler and Van Lancker (2002) study, they reported that there was an improvement in intelligibility in the spontaneous singing condition; however, there was also a significant increase in loudness, indicating that increased breath support or increased volume may account for the improvement in intelligibility. In the Pilon, McIntosh and Thaut (1998) study, the authors are manipulating and examining speech rate rather than the speech tasks themselves which is not what is being directly examined in this critical analysis. They found that a decreased speech rate (in all conditions, including singing) resulted in increased intelligibility in two of the participants. Tamplin (2008) taught the participants vocal exercises and encouraged them to use these when singing. Therefore, the participants in this study may have been using these vocal exercises as they were singing, resulting in a change in their singing voice that was not a result of singing, but of the vocal exercises. Similarly, in the Magee et al. (2006) study, the participants used techniques such as relaxation, breath control and vocal activities which may have resulted in increased intelligibility and an increase in voice quality, instead of these characteristics improving as a direct result of singing.

Overall, the participants in these studies all varied in the type and severity of dysarthria. In addition, many of the participants had dysarthria as a result of a variety of different causes. This means that each individual was a very specific case and therefore it is not easy to generalize these results to other adults with dysarthria.

Clinical Implications

Currently, the available evidence suggests that incorporating singing into speech therapy for adults, who have dysarthria, may be beneficial, as there is a trend among the studies that singing improves intelligibility and other speech characteristics in many of the cases above. However, further research, including randomized control trials with more participants, in this area is needed.

References

Darley, Aronson, & Brown (1969). Clusters of deviant speech dimensions in the dysarthrias. *Journal of Speech and Hearing Research, 12*, 462-496.

Duffy, J. R. (2005). *Motor speech disorders: Substrates, differential diagnosis, and management (2nd ed.).* Missouri, United States of America: Elsevier.

Kempler, D., & Van Lancker, D. (2002). Effect of speech task on intelligibility in dysarthria: A case study of Parkinson's disease. *Brain and Language, 80*, 449-464.

Magee, W. L., Brumfitt, S. M., Freeman, M., & Davidson, J. W. (2006). The role of music therapy in an interdisciplinary approach to address functional communication in complex neuro-communication disorders: A case report. *Disability and Rehabilitation, 28(19),* 1221-1229.

Pilon, M. A., McIntosh, K. W., & Thaut, M. H. (1998). Auditory vs visual speech timing cues as external rate control to enhance verbal intelligibility in mixed spastic ataxic dysarthric speakers: a pilot study. *Brain Injury, 12(9),* 793-803.

Tamplin, J. (2008). A pilot study into the effect of vocal exercises and singing on dysarthric speech. *NeuroRehabilitation, 23,* 207-216.

Tamplin, J. & Grocke, D. (2008). A music therapy treatment protocol for acquired dysarthria rehabilitation. *Music Therapy Perspectives, 26(1),* 23-29.