Critical Review: Do Behavioural Compensatory Strategies Lead to Better Speech Outcomes in Individuals with Dysarthria Secondary to Multiple Sclerosis (MS)?

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This review critically analyzes the effect of behavioural compensatory strategies on speech outcomes, including intelligibility, on those with dysarthria secondary to Multiple Sclerosis. Behavioural compensatory strategies are common treatment approaches for dysarthria, especially when it is secondary to a neurological disorder, however, research on its impact on those with dysarthria secondary to Multiple Sclerosis is lacking. The literature reviewed included five within-subject designs, the results yielding suggestive to highly suggestive evidence that various behavioural compensatory strategies have a benefit on speech outcomes within this demographic.

Introduction

Multiple Sclerosis (MS) is a chronic, autoimmune disease of the central nervous system, where myelin surrounding the nerves becomes inflamed and damaged (MS Society of Canada). Canada has one of the highest rates of MS in the world. Currently, there are around 2.8 million people living with MS, approximately 90,000 of those people are in Canada alone (MS Society of Canada). In terms of symptoms, dysarthria is observed to be the most frequent communication disorder in those with MS. Symptoms of dysarthria can range in severity depending on neurological involvement; however, most cases are mild to moderate in severity. Dysarthria types typically seen in those with MS include spastic, ataxic, and mixed, with mixed being the most common. The National MS Society states that common complaints of those diagnosed include, difficulty with precision of articulation, speech intelligibility, ease of conversational flow, speaking rate, loudness, and voice quality (Miller, 3).

As there is no cure for Multiple Sclerosis and most medical interventions focus on alleviating physical symptoms, various behavioural compensatory strategies are used to help manage symptoms of dysarthria. Some of these strategies include reducing articulatory rate (i.e., slow speech), speaking using a clear rate (i.e., exaggerated speech), and increasing vocal intensity (or increasing loudness).

Evidence-based research analyzing the effects of various behavioural compensatory strategies on speech outcomes in individuals with dysarthria secondary to Multiple Sclerosis is imperative for clinicians and clinical decision making. Understanding the effects of these strategies on speech outcomes, like intelligibility, within this population will not only provide insight into which strategies may be the most beneficial, it can also provide information on which strategies may be detrimental to speech. Having this knowledge will allow clinicians to make the clinical decisions that are necessary when deciding on a treatment approaches while also ensuring they are providing the best care possible.

Objectives

The primary objective of this critical review is to examine literature to determine current evidence for the effectiveness of behavioural compensatory strategies on speech outcomes in those with dysarthria secondary to Multiple Sclerosis and how these findings may guide clinical decision making in dysarthria treatment.

Methods

<u>Search Strategy</u>
Articles related to the topic of interest were discovered using the following search databases: EBSCOhost, PubMed, and Western Libraries. The following search terms were used:
[(dysarthria) AND (Multiple Sclerosis) AND (treatment)]
[(dysarthria) AND (Multiple Sclerosis) AND (compensatory strategies)]

<u>Selection Criteria</u>
Studies were selected for inclusion in this review paper if they investigated different behavioural compensatory strategies and their influence on speech outcomes in people with dysarthria secondary to MS. For the purposed of this review, I included only data and analysis relevant to participants with both a diagnosis of dysarthria and MS. The majority of studies also included analysis relevant to participants diagnosed with dysarthria and Parkinson's disease (PD). Due to the large

number of studies and data focused on dysarthria and dysarthria treatments in those with PD, I chose to not consider results focused on PD participants in the overall conclusions of the critical review.

Data Collection

Results from the literature yielded five articles consistent with the previously mentioned search strategy and selection criteria, all of which were within-subject designs.

Results

Tjaden & Wilding (2004) examined how reduction in articulatory rate and an increase in vocal loudness affected the acoustic output of the vocal tract in those with dysarthria secondary to Multiple Sclerosis and Parkinson's disease. The effects of how these behavioural compensatory strategies impacted intelligibility was also of interest. This study included a total of 42 individuals, 15 of whom with MS (10 women and 5 men, between the ages of 25-62 years old), and the remainder being a mix of those with PD and healthy controls. All participants were matched appropriately for background and auditory skills. Individuals with MS had a diagnosis of mild, moderate or mild/moderate dysarthria based on the consensus of three speech-language pathologists using a variety of measures. Intelligibility estimates were provided by ten listeners (9 women and 1 man) who had minimal to no clinical or research experience with dysarthria.

Using a sound-treated booth, each participant was audio recorded while reading a 192-word passage selected for the study. This passage was selected based on the number of occurrences of the vowels /i/, /ɑ/, /æ/, and /u/ and the consonants /s/, /ʃ/, /t/, and /k/, all speakers read the selected passage in habitual, loud and slow conditions. Following the habitual condition, half of the participants read the passage in loud and then slow conditions and the other half in slow then loud. Articulatory rate, or the rate of the participants speech, was obtained by sectioning each passage into runs and then counting the syllables produced in each run. A run was defined as a "stretch of speech bounded by silent periods between words of at least 200 ms". Sound pressure level (SPL) was used to identify variations in voice intensity, these were also averaged, and a mean was yielded for each participant and speaking condition. F1 & F2 values for both the vowels occurring in stressed syllables were measured to calculate the vowel space area as this may have an effect on speech intelligibility and severity. Finally, first-moment difference measures were also used to analyze articulatory working space for the consonants listened above. This was of interest to measure any articulatory distinctiveness and its effect on speech perception.

Appropriate statistical analyses were performed. A mixed linear model was used to calculate the impact of each speaking condition (habitual, loud, and slow) on all dependent variables (SPL, articulatory rate, vowel working space, first-moment difference, and F2 slopes). It was found that for the MS group, 11/15 speakers showed a larger vowel working space in the slow condition, which allows for greater vowel distinctiveness. In the loud condition, there were minimal changes to stop and fricative consonant working spaces. The authors indicated that these slight changes may be because these specific working spaces are relatively preserved in those with mild to moderate dysarthria secondary to MS. Finally, it was established that intelligibility was not improved in either speaking condition for the MS participants. This may be indicative of the relatively preserved intelligibility within this population.

Strengths of this study include their use of a control group and the excellent intrajudge and interjudge reliability (0.99) for SPL, F1 & F2 measures, and first moment differences. Limitations included the small sample size and the lack of standardized dysarthria tool, other than the Sentence Intelligibility Test (SIT), used by the speech-language pathologists. Overall, this study yielded suggestive evidence that the behavioural compensatory strategies of rate reduction and increased vocal loudness may improve vowel and consonant distinctiveness in those with dysarthria secondary to MS. However, there was no strong evidence that either of these strategies improved intelligibility within this population.

Tjaden & Wilding (2011) analyzed the effects of reduced articulatory rate and increased vocal loudness on various fundamental frequency characteristics in individuals with a diagnosis of dysarthria secondary to either Multiple Sclerosis or Parkinson's disease. The effects of how these compensatory strategies impacted intelligibility was also of interest. The study was comprised of 40 participants, 15 of whom with MS (5 men and 10 women, between the ages of 25-62 years old), and the remainder being a combination of those with PD and healthy controls. Three speech-language pathologists came to a consensus on dysarthria diagnoses, deviant perceptual characteristics and severity estimates for each MS participant. Intelligibility estimates were also provided by five speech-language pathology graduate students. Recordings were acquired in a sound-treated booth using CSpeechSP 4.0 and a AKG C410 head-mounted mic.

Each participant was audio recorded while reading a 192-word passage that was chosen for the study. The first 98 words (six sentences) were analyzed. The passage included a broad range of consonants and vowels to ensure the analysis of a variety of speech sounds. Each participant read the passage in habitual, loud, and slow speaking conditions. Using CSpeechSP 4.0, articulatory rate, or the rate of the participant's speech, was analyzed for each speech run, which was defined as a "stretch of speech bounded by silent periods between words of at least 200 ms". Sound pressure level (SPL) was also used to identify variations in the participants' voice intensity. Fundamental frequency (F_0) traces were analyzed for each speech run using the computer program TF32. Each run was inspected by two trained research assistants who were not familiar with the current study. Statistics for each F_0 measure include mean, standard deviation, minimum, maximum, range, interquartile range as well as slope.

Appropriate statistical analyses were performed. A multivariate linear model was used to determine the effect of speaking conditions on each dependent variable (articulatory rate, SPL, F_0). Results revealed that 34/40 speakers had a greater F_0 range in the loud condition, suggesting that an increase in vocal intensity can improve articulatory rate, SPL and fundamental frequency. In contrast, it was found that reducing articulatory rate up to 75% of habitual speech rate, may have a negative impact on fundamental frequency measures (mean, maximum, and range). Based on these results, the authors suggested that focusing on increasing vocal intensity would be of benefit in dysarthria treatment as this may increase intelligibility.

Strengths of this study included the use of a control group and excellent intrajudge and interjudge reliability (0.99) for speech run duration, F_0 measures (ranging from 0.92-0.99) and slope (0.95). Weaknesses of this study included a small sample size that mostly included participants with mild and moderate dysarthria. While it is not atypical for studies to have small sample sizes targeting this population, it can make it difficult to generalize these results to a therapeutic setting. Overall, the results of this study provide suggestive evidence that behavioural compensatory strategies focusing on increased vocal intensity can have positive impacts on F_0 measures in dysarthric speech, which may contribute to higher intelligibility. However, the opposite is true for slowed articulatory rate which can lower levels of F_0 measures and have a negative effect on intelligibility in those with dysarthria secondary to MS.

Tjaden, Lam & Wilding (2013) wanted to identify the impact of clear speech, increased vocal intensity and rate reduction on vowel acoustics in individuals with Multiple Sclerosis and Parkinson's disease. Participants included 39 speakers, 11 of whom with MS (5 men and 6 women, mean age of 55 years) and the remainder being those with a either a diagnosis of PD or healthy controls. All participants were matched appropriately for background and auditory skills. Intelligibility and speech severity scores were collected using *The Grandfather Passage* and the Sentence-Intelligibility Test (SIT) by three speech-language pathologists. These scores were used to identify a perceptible dysarthria in speakers with MS and PD.

In a sound-proof room using a AKG C410 head-mounted mic, all speakers were audio-recording while reading 25 *Harvard Sentences*. These sentences were selected to ensure the occurrences of the four peripheral vowels (/ɑ/, /æ/, /i/, and /u/) and the four nonperipheral vowels (/ɛ/, /ʊ/, /ɪ/, and /ʌ/). These vowels were of specific interest as they may be affected by changes in speech rate and clarity. Participants were instructed on how to talk in each speaking condition which included habitual, clear, loud and slow conditions. Each sentence was typed onto cards and randomly ordered. Participants first produced the sentences in habitual condition, with the rest of the speaking conditions being randomized. Using TF32 software to analyze speech acoustics, sentences were segmented into speech runs, a run was defined as a "stretch of speech bounded by silent periods between words of at least 200 ms". Articulatory rate and SPL were obtained for all speakers for the purposes of determining how much the speaking conditions affected the timing and intensity of the participant's speech. Vowel durations were also obtained to explore how each speaking condition affected the timing of vowel segments.

Appropriate statistical analyses were performed. A multivariate linear model was used to determine the effect of each speaking condition (clear, loud, and slow) on each dependent variable for vowel acoustics (articulatory rate, SPL, segmental timing, and vowel spectral measures). In regards to vowel acoustics in MS speakers, it was determined that the clear speaking condition increased vowel segmenting the most, however, some MS speakers saw an increase in vowel distinctiveness in the loud condition. In terms of vowel spectral changes, it was unexpectedly found that MS speakers had greater vowel working spaces than controls in the habitual, loud and slow speaking conditions. Leading to the loose hypothesis that vowel articulation and production may be fairly intact in those with dysarthria secondary to MS.

Strengths of this study include the use of a control group, the randomization of both the sentences produced by all speakers and the order in which they were produced. In addition to these strengths, measurement reliability was excellent (between 0.98-0.99) for both intra- and interjudge reliability. Limitations within the study include the small sample size and the lack of standardized dysarthria assessment used when identifying dysarthria severity in both MS and PD speakers. This study was also not a long-term training study, therefore maintenance and generalization to a clinical setting should be considered with caution. Overall, the results of this study provide suggestive evidence that in MS speakers with dysarthria, both the clear and loud speaking conditions can enhance various vowel acoustic measurements.

Tjaden, Sussman & Wilding (2014) studied the effect of rate reduction, increased vocal intensity and clear speech on intelligibility and speech severity (degree of speech impairment) in those with dysarthria secondary to Multiple Sclerosis or Parkinson's disease. Participants included 78 speakers, 30 of whom with MS (10 men and 20 women, between the ages of 27-66 years old) and the remainder being those with a diagnosis of PD and healthy controls. All speakers with dysarthria were required to have a formal medical diagnosis of either PD or MS to participate. Participants were matched appropriately for background and auditory skills. Percent correct word, sentence intelligibility scores and speech severity scaled estimates for *The Grandfather Passage* were reported to help illustrate each speaker's speech characteristics.

Following verbal instructions for each condition, participants were recorded while reading 25 *Harvard Psychoacoustic Sentences* with between seven and nine words, in habitual, slow, loud, clear, and fast conditions. For the purposes of this study, only the first four conditions (presented in a random order) were analyzed. Articulatory rate and mean sound pressure level (SPL) were also determined. Speech intelligibility was rated by 100 listeners: 50 scored overall intelligibility and the other 50, speech severity. Intrajudge reliability was identified to be between .60-.88 (moderate to good) for both intelligibility and speech severity scoring.

Appropriate statistical analyses were performed. A multivariate linear model was used to analyze the effect of each speech condition (habitual, slow, loud, and clear) on the dependent variables (articulatory rate and SPL) for each group (control, MS, and PD). Results indicated that all speaker groups significantly decreased their articulatory rate in the slow condition and significantly increased mean SPL in the loud condition. It was also noted that the MS and control groups slowed their articulatory rate in the loud condition when compared to the habitual. Finally, all groups increased their mean SPL and decreased their articulatory rate in the clear condition. For participants with MS, intelligibility and speech severity were best in the loud condition, followed by the clear condition and poorest in the slow condition.

Strengths of this study include the detailed eligibility criteria for the participants as well as the blinding of the listeners when evaluating sentences. Limitations within the study include the small sample size and the potential variation in instructions provided to the participants before each condition task. Overall, this study provides highly suggestive evidence that behavioural compensatory strategies that focus on increasing loudness or exaggerating articulation, have an overall positive effect on intelligibility in those with dysarthria secondary to MS, while strategies that focus on slowing rate of speech have the adverse effect.

Tjaden & Martel-Sauvageau (2017) sought to determine the impact of clear speech and increased vocal intensity on consonant acoustics in those with mild dysarthria secondary to Multiple Sclerosis or Parkinson's disease. The study included 37 participants, 11 of whom had a diagnosis of MS (5 males and 6 females, with a mean age of 55 years) and the remainder being a combination of those with a diagnosis of PD and healthy controls. All participants were matched appropriately for background and auditory skills. Intelligibility and speech severity scores were collected by three speech-language pathologists using *The Grandfather Passage* and the Sentence-Intelligibility Test (SIT) to identify a perceptible dysarthria in speakers with MS and PD.

In a sound-treated booth, speakers were audio-recorded while reading 25 *Harvard Sentences* in habitual, clear and loud speaking conditions. To analyze spectral characteristics of fricatives and plosives in different word positions, sentences were selected based on the number of occurrences of the speech sounds /t/, /k/, /s/ and /ʃ/ in word-initial and word-medial position. All speakers read each sentence in habitual condition first to establish a baseline, the rest of the speaking conditions were then randomized. Nonhabitual conditions (clear and loud), were also carefully counterbalanced to control for any order effects. Using TF32 software to analyze speech acoustics, sentences were segmented into speech runs, a run was defined as a "stretch of speech bounded by silent periods between words of at least 200 ms". Articulatory rate and SPL were obtained for all speakers for the purposes of ensuring that both the clear and loud conditions differed from habitual in all speakers. Moment coefficients (mean, standard deviation, skewness, and kurtosis) were acquired for each consonant, however, the first moment coefficient (M1), or the spectral mean, was the main interest, as changes within it may suggest more anterior articulation or less articulatory displacement in those with dysarthria.

Appropriate statistical analysis were performed. A multivariate linear model was used to determine the effect of each speech condition (habitual, clear, and loud) on each dependent variable (articulatory rate, SPL, and moment coefficients) for each speaker group (MS, PD, and control). Results showed that all speaker groups appropriately reduced their articulatory rate and increased their SPL in the clear condition and increased their SPL in the loud condition. In terms of the first moment coefficient (M1), it was established that the MS group showed greater spectral contrasts in the clear speaking condition for fricatives /s/ and /ʃ/ in word-initial position. For the stop consonants /t/ and /k/, greater spectral changes were seen in word-initial position for /t/ and word-medial for /k/, both in the loud condition. These results indicate that clear speech and increased vocal loudness may have a positive effect on some consonant acoustics, with the majority of contrasts being seen in the word initial position.

Strengths of this study include the randomization and controlling of any order effects for speaking conditions. Limitations include the small sample size and that they only saw subtle changes between the habitual, clear and loud speaking conditions. Considering these outcomes, the results provide suggestive evidence that behavioural compensatory strategies involving clear speech and increased vocal intensity, may have a positive effect on consonant acoustics, especially in the word initial position, in those with dysarthria secondary to MS.

Discussion

This critical review sought to determine if behavioural compensatory strategies lead to better speech outcomes in those with dysarthria secondary to Multiple Sclerosis. Overall, the results of this critical review showed suggestive to highly suggestive evidence that behavioural compensatory strategies, particularly increased vocal intensity and clear speech, did have a positive effect on speech outcomes in those with dysarthria secondary to Multiple Sclerosis.

There were various limitations within the literature analyzed that should be considered and discussed. To begin, all studies included in this critical review incorporated small sample sizes. Although this is not uncommon for studies concentrated on individuals with neurodegenerative diseases, it ultimately affects the overall strength of the results yielded. Another limitation within the samples is the inclusion of both participants with Parkinson's disease and Multiple Sclerosis. Research is lacking on how behavioural compensatory strategies benefit and hinder speech outcomes in individuals with Multiple Sclerosis, therefore, it would have been of benefit to have studies that only focused on behavioural compensatory strategies in Multiple Sclerosis participants. Additionally, within the studies analyzed, only participants with either mild or moderate dysarthria were included. Although it is more common for those with Multiple Sclerosis to have mild to moderate dysarthria symptoms, in a clinical setting where you may encounter a client with more moderately-severe to severe dysarthria symptoms, these results may be difficult to generalize. Another limitation and potentially the greatest, was that none of the studies analyzed in this review implemented these behavioural compensatory strategies as a long-term or treatment study, rather, they were examined from a comparison and consequential perspective. This not only has an impact on how clinicians can generalize these results to a clinical setting, it also does not give us insight on how functional these strategies are for those with dysarthria secondary to Multiple Sclerosis and if these strategies can be maintained over an extended period of time in more natural speaking environments.

Future considerations may include larger sample sizes with only individuals with dysarthria secondary to Multiple Sclerosis and healthy controls to help strengthen the results of behavioural compensatory strategy outcomes within this particular population. Conducting treatment studies using various compensatory strategies within this population would also be of benefit to both the research and clinical environments.

Conclusion

Overall, more research needs to be conducted to better understand the impacts of various behavioural compensatory strategies on speech outcomes in those with dysarthria secondary to Multiple Sclerosis. Within these speech outcomes, speech intelligibility scores resulting from behavioural compensatory strategies also needs to be looked at further. Of all the studies analyzed in this critical review, only two closely analyzed the effects of the targeted compensatory strategies on participant's speech intelligibility. As speech intelligibility is a common concern in those with dysarthria secondary to Multiple Sclerosis, it would be beneficial for future research to explore this area more in depth.

Clinical Implications

Even though the literature analyzed in this critical review yielded suggestive evidence that some behavioural compensatory strategies do lead to positive speech outcomes in those with dysarthria secondary to Multiple Sclerosis, there is still a lack of research within this area. Due to this and the limitations discussed above, results yielded within these studies should be carefully considered before applying them to a clinical setting. Clinicians should also remember that deciding on which behavioural compensatory strategies to implement in treatment will vary greatly between individuals due to the variability in symptoms and the clients goals.

Most importantly, when working with those with dysarthria secondary to Multiple Sclerosis, speech-language pathologists should work together with the client, caregivers and other health care professionals to determine which strategies will be most functional for the client. It is imperative to remember that functionality of compensatory strategies will be dependent on the type and severity of the clients Multiple Sclerosis diagnosis, the type, severity, and presenting symptoms of their dysarthria and any cognitive impairments that are present secondary to the Multiple Sclerosis diagnosis as these may impact the execution of the strategies.

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