

Treatment of Ataxic Dysarthria Using a Modified Be Clear Approach: A Pilot Study

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Abstract

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Ataxic dysarthria is a motor speech disorder characterized by irregular articulatory errors as well as changes to prosody, such as atypical variability in loudness, pitch and stress (Duffy, 2020). Like many other motor speech disorders, ataxic dysarthria can impact an individual's quality of life, affecting social participation, well-being, and mental health (Daker-White et al., 2015; Jacobi et al., 2018). To date, treatment studies specifically designed for speakers with ataxic dysarthria have been limited. The present study examined the viability of a tailored speech treatment that builds on the established Be Clear (Park et al., 2016) and ClearSpeechTogether (Lowit et al., 2023) approaches. In this pilot study, two speakers with ataxic dysarthria participated in an 8-week treatment administered remotely. Strategies focused on overenunciation and slowed rate via phrasing. Ten listeners conducted blinded perceptual ratings of articulation clarity and speech naturalness across three time points (pre-treatment, immediately post-treatment, and 1-month maintenance). Outcome measures of transcription intelligibility and psychosocial impact were also included. Results suggest improvements across perceptual ratings of intelligibility and naturalness, as well as pronounced increases to sentence-level intelligibility. Post-treatment changes to measures of dysarthria impact and communication

participation were mixed. Additional research is required to establish efficacy with a larger and more diverse sample.

Table of Contents

Abstract	3
Acknowledgement	9
Introduction	10
<i>Cerebellar impairment</i>	11
<i>Ataxic dysarthria</i>	12
<i>The clear speech approach</i>	18
<i>Clear speech and ataxic dysarthria</i>	19
<i>Research questions</i>	20
Methods	21
<i>Phase 1</i>	22
Speakers.....	22
Speaker protocol.....	22
Zoom session logistics.....	23
Assessments.....	23
Treatment (modified Be Clear).....	24
Data processing.....	28
<i>Phase 2</i>	28
Listeners.....	28
Listener protocol.....	28
Results	30
<i>Participants (Speakers)</i>	30
<i>Participants (Listeners)</i>	31
<i>Modified Be Clear treatment</i>	31
Adherence.....	31
Paired Comparison Ratings.....	31
Intra-Rater Reliability.....	34
Outcome Measures.....	35
Discussion	37

<i>Alignment with hypotheses and extant literature</i>	37
<i>Potential influences on treatment outcomes</i>	39
<i>Limitations and future directions</i>	41
Conclusion	40
References	41
Appendix A: Inclusionary/exclusionary screening.....	48
Appendix B: Daily communication questions	49
Appendix C: Practice stimuli examples.....	50

List of Figures

Figure 1: Screenshot of listener rating screen.....	29
Figure 2: Frequency counts for pre-treatment vs. post-treatment ratings of intelligibility and naturalness for both speakers	32
Figure 3: Frequency counts for pre-treatment vs. 1-month maintenance ratings of intelligibility and naturalness for both speakers	33
Figure 4: Frequency counts for post-treatment vs. 1-month post maintenance ratings of intelligibility and naturalness for both speakers	33
Figure 5: Overall listener preferences for intelligibility and naturalness pooled across all paired comparisons	34
Figure 6: Outcome measures for psychosocial impact per speaker (S1 and S2) on the DIP and CPIB across time points.....	36

List of Tables

Table 1: Components of the modified Be Clear treatment protocol	27
Table 2: Demographic and Clinical Characteristics of Participants with Ataxic Dysarthria	30
Table 3: Summary of Treatment Outcome Measures	36

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The cerebellum, often referred to as the “little brain,” is located at the base of the skull, posterior to the brainstem. In general, the cerebellum is responsible for the control of movement and balance. It is abundantly connected throughout the central nervous system to ensure the smooth coordination of movement and to contribute to non-motor functions, such as cognition, vision, and emotional processing. While it comprises only 10% of brain volume, the cerebellum contains over 50% of the brain’s total neurons (Silver, 2018), reflecting the integral role it plays across a wide variety of functions.

The main body of the cerebellum can be divided into two hemispheres, separated by the midline or vermis. The lateral cerebellar hemispheres have an anterior lobe which is broadly responsible for providing proprioceptive information to regulate gait and posture, and a posterior lobe which is generally responsible for coordinating voluntary muscle activity (Duffy, 2020). Cerebellar connections to important structures, such as the cerebral cortex, basal ganglia, brainstem, and spinal cord facilitate the integration, coordination, and execution of smooth movements. More specifically, the cerebellar control circuit provides feedback to the rest of the brain about the timing and force required for a particular movement, resulting in a movement that is fluid and coordinated. Beyond these primary functions, the cerebellar control circuit is essential to numerous aspects of motor control, such as maintaining balance (Surgent et al., 2019), coordinating eye movements to optimize visual perception (Beh et al., 2017); Silver, 2018), error correction (Therrien & Bastian, 2015), predicting the sensory consequences of movement (Prati et al., 2024), and motor learning (Kozioł et al., 2014)

The cerebellar control circuit also contributes to the smooth production of speech. By sequencing the movements of agonist and antagonist muscles, the cerebellar control circuit can refine muscle activity to produce the appropriate amount of force and timing for speech (Duffy, 2020). As such, the cerebellar circuit helps to shape the temporal and prosodic properties of speech, and subserves the online sequencing of syllables into fast, smooth, and rhythmically organized utterances (Ackermann et al., 2007). Additionally, the cerebellar circuit contributes to error correction by checking the adequacy of speech outcomes based on auditory and other feedback from speech muscles, tendons, and joints (Duffy, 2020). Over time, the cerebellum learns from this sensory feedback and is hypothesized to acquire “internal models” of movement; these models allow us to compare predicted speech movements with actual speech outcomes

(Moberget & Ivry, 2016). Thus, the cerebellar circuit is fundamentally involved with many aspects of speech motor control (Callan & Manto, 2021).

Extending beyond motor functions, the cerebellum is connected to areas of the brain responsible for cognitive and affective functions, such as the prefrontal cortex and limbic system, giving it a role in non-motor functions as well. It is well established that the cerebellum contributes to cognitive functions, such as attention, working memory, and executive functions (Zhang et al., 2023), as well as emotional processes, such as the detection of emotional stimuli and autonomic responses to emotional stimuli (Prati et al., 2024). Additionally, the cerebellum is implicated in reward-driven learning and emotional learning, such as fear conditioning which involves the formation, consolidation, and extinction of fear memories (Ernst et al., 2019; Rudolph et al., 2023). As such, the cerebellum contributes considerably to non-motor processes, despite the historical tendency to view this circuit as exclusively motor based.

Cerebellar Impairment

Given the broad contributions to motor and non-motor functioning, disruption to the cerebellar control circuit can lead to a wide variety of challenges. Ataxia is most prominent, reflecting an overall lack of movement coordination. Balance and equilibrium difficulties are often pronounced and can lead to gait instability and falls. Along with these challenges, tremors may emerge, particularly intention tremors, which are rhythmic tremors that come about during a directed movement and become worse near the endpoint of the movement. Vision abnormalities can manifest as inconsistent, irregular saccades (rapid eye tracking movements), nystagmus (repetitive eye shaking), and deficits in visual perception (Therrien & Bastian, 2015). Speech can be disrupted, particularly changes to articulation and prosody, leading to decreased intelligibility and naturalness.

Non-motor manifestations of disruption to the cerebellar control circuit include cognitive challenges such executive dysfunction (e.g. problem solving, inhibition, and task planning, cognitive flexibility; (Liu et al., 2022); Shin et al., 2024), reduced visuospatial skills (Slapik et al., 2019) and impaired attentional processes (Mannarelli et al., 2023). Changes to affect include impaired ability to recognize emotions in others, particularly negative emotions (Prati et al., 2024). The frequent pairing of cognitive and affective challenges from cerebellar disruption has led to the designation of syndromes, such as Cerebellar Cognitive Affective Syndrome (CCAS;

(Hoche et al., 2018) and Posterior Fossa Syndrome (Lanier & Abrams, 2017). CCAS is characterized by deficits in executive function, linguistic processing, spatial cognition, and affect regulation. Similarly, Posterior Fossa Syndrome, which most commonly arises in childhood from a medulloblastoma in the posterior fossa region (brainstem and cerebellum), leads to emotional lability, distractibility, withdrawal, mutism/dysarthria, and ataxia (Lanier & Abrams, 2017).

The two most common categories of etiologies of cerebellar impairment are degenerative and vascular (Duffy, 2020). Often, the cause of degeneration of the cerebellum is unknown; however, there are numerous known hereditary conditions. Most notably, hereditary spinocerebellar ataxias (SCA) are a group of inherited ataxias that primarily cause progressive loss of motor function. There are more than 30 types of SCA, which are numbered according to the discovery of the particular gene mutation; most common are SCA 1, 2, 3, and 6 (Soong & Morrison, 2018). Characteristics of SCA can differ with each type, but most SCAs present with loss of coordination and balance, dysarthria and dysphagia, and vision problems (Sullivan et al., 2019). Vascular etiologies, such as strokes or hemorrhages, are considerably less prevalent than degenerative etiologies. Blood is supplied to the cerebellum through three main arteries—the posterior inferior cerebellar artery (PICA), the anterior inferior cerebellar artery, and the superior cerebellar artery. Vascular disruptions to the PICA are most common (Cano et al., 2012). Strokes that occur in any of these three arteries can result in gait unsteadiness, limb or trunk ataxia, or dysarthria (Salerno et al., 2022). Other causes of cerebellar damage include tumors, gluten ataxia (Kharrazian, 2020), traumatic brain injury, demyelinating diseases such as multiple sclerosis, or chronic alcohol use (De Silva et al., 2019).

Ataxic dysarthria

Most relevant to this project is the disruption to speech caused by damage to the cerebellum, referred to as ataxic dysarthria. Ataxic dysarthria is a motor speech disorder characterized by irregular articulatory errors as well as changes to prosody, such as atypical variability in loudness, pitch and stress during speech. Also common are disorganized speech breathing patterns and telescoping or blurring of syllables (Duffy, 2020). Ataxic dysarthria can be very heterogeneous in its presentation. As a result, subgroups of ataxic dysarthria have been proposed (Spencer & France, 2016; Spencer & Dawson, 2019; Duffy, 2020; Spencer et al., 2023). Broadly speaking, the subgroups represent a primary disruption to prosody versus a

primary disruption to articulation. Speakers with the prosodic subtype tend to present with a decreased rate and equalized, isochronous production with reduced variation of pitch or volume (Spencer & France, 2016). Speakers with predominant articulatory inaccuracy (Duffy, 2020) also tend to present with incoordination of breathing with speaking, and highly variable pitch, loudness, and rhythm (Spencer & France, 2016). While these subgroups are not universally acknowledged, there is growing evidence supporting the identification and recognition of the contrasting speech patterns.

Ataxic dysarthria, like other communication disorders, can have a significant impact on an individual's quality of life. Communication plays an important role in interpersonal connection and navigating activities of daily living, such as asking for items at a grocery store or making a phone call to loved ones. The decreased intelligibility and naturalness associated with dysarthria can negatively impact subjective well-being (Piacentini et al., 2014; Jacobi et al., 2018) and can limit communication participation (Page & Yorkston, 2022). Specific to ataxic dysarthria is the added stigma that speech and overall movements are similar to someone who is intoxicated. Many people with ataxic dysarthria have reported that people believe they sound “drunk” when they speak (Mercadillo et al., 2015). This erroneous assumption can lead to insecurity and a decrease in social participation and financial well-being (Daker-White et al., 2015). The progressive nature of ataxic dysarthria with some etiologies also contributes to mental health challenges, such as anxiety and depression (Jacobi et al., 2018).

Treatment of ataxic dysarthria

Treatment studies for ataxic dysarthria are emerging but limited. Given the considerable impact that ataxic dysarthria may have on an individual's quality of life, there is a compelling need for research for treatment of this motor speech disorder.

In 2003, Sapir and colleagues sought to determine whether the effects of Lee Silverman Voice Treatment (LSVT; (Fox et al., 2006), a dysarthria treatment intended for Parkinson's disease, would improve ataxic dysarthria. The study had one participant, a 48-year-old woman with a 16-year history of cerebellar dysfunction caused by thiamine deficiency encephalopathy. She demonstrated reduced coordination, irregular articulatory breakdown, a slow rate of speech, and breathy vocal quality. Outcome measures were collected three consecutive days before treatment and two consecutive days after treatment, followed by one session 9 months after

treatment. Data included acoustic measures, such as sound pressure level (SPL) and formant frequencies, and perceptual ratings of speech intelligibility and intonation. Intelligibility was measured by percent of intelligible words in noise, a rating scale of ease of intelligibility, and a ratio of these two measures. The participant also completed the Minnesota Satisfactoriness Scale to determine satisfaction with participation and performance in the workplace. Treatment was administered within the typical timeframe for LSVT, which is 16 sessions during a 4-week period. Emphasis was placed on maximizing phonatory efficiency and loudness, and increasing self-perception of loudness and vocal effort, as well as promoting generalization and maintenance of these skills. Results showed that SPL and intelligibility increased (based on the ratio of percent of intelligible words/ease of intelligibility), as well as participant satisfaction with her performance in the workplace. The follow-up assessment showed that acoustic measures like SPL and formant frequency improved from pre-treatment. Articulatory precision also showed significant improvement from pre-treatment in the post-treatment and follow-up assessments. The authors acknowledged that a single participant provides very limited data, and that LSVT may have worked especially well for her because she presented with weak voice and breathiness.

In 2019, Vogel and colleagues examined an intensive home-based speech treatment for participants with Autosomal Recessive Spastic Ataxia of Charlevoix-Saguenay (ARSACS), which is a multisystemic degenerative ataxia. Seven participants took part in the 4-week treatment, as well as the assessments done 4 weeks prior to treatment, immediately before treatment, and immediately after treatment. The intervention consisted of practicing daily tasks, such as the production of words and sentences, repetition of long vowels, loudness and pitch control exercises, repetition of short phrases to target prosody, reading, and answering a question in a naturalistic manner. Treatment was comprised of 45-minute sessions a day, 5 days per week, for 4 weeks. Participation and upkeep were monitored by weekly telephone calls from a speech therapist. The treatment also utilized a program called Melbourne Ataxia Speech Treatment (MAST; Vogel et al., 2019). MAST used multi-sensory feedback on a laptop to optimize self-monitoring opportunities. Three types of feedback were provided to the participants— (1) listening feedback, where the participant could listen to themselves speak and develop self-monitoring skills, (2) delayed results-based feedback on duration, loudness variation, and pitch variation provided by plots on MAST, and (3) real-time visual feedback provided by the real-

time loudness and pitch displays on MAST. Judgments were made by raters that were blinded to assessment time period. Results showed that the participants' intelligibility, as measured by expert ratings using Direct Magnitude Estimation (DME), increased significantly in both reading contexts and naturalistic monologue contexts. Naturalness also increased significantly based on perceptual ratings from listeners, using speech stimuli that has been proven to be reliable, stable, and sensitive to change. These results are promising; however, this study did not include a maintenance measure to determine how the treatment continued to affect these outcome measures longer term.

Vogel and colleagues conducted a follow-up study in 2022 utilizing home-based biofeedback with 16 participants with CAG repeat-expansion SCA (CAG-SCA). Treatment followed a similar schedule to the previous study, which was 45-minute sessions, 5 days a week, for 4 weeks. Assessments were also based on a similar schedule, 4 weeks prior to treatment, immediately before treatment, and immediately after treatment. The home-based treatment program utilized MAST like the previous study to provide real-time visual and aural feedback. Three outcome measures were used to gauge treatment success: rater-blinded intelligibility, rater-blinded perceptual ratings (prosody, respiration, phonation, resonance), and acoustic features of timing, vocal control, and vocal quality. The researchers reported a statistically significant improvement to intelligibility, as well as general improvements to the perceptual measures and speech rate, supporting the idea that MAST may be beneficial for those with SCA. The authors state that future research should seek to examine a larger sample size with a control group, and to explore long term effects of treatment.

Sonoda and colleagues (2020) conducted a study to determine how intensive, structured speech therapy affected dysarthria and speech-related quality of life in people with sporadic spinocerebellar degeneration (SCD). Twenty-two participants that were receiving outpatient care for their SCD were recruited to the study and underwent intensive treatment in the inpatient unit of the hospital, 5 times a week for 4 weeks. Treatment was provided by a physical therapist, occupational therapist, and speech therapist at separate times; 40 minutes per session were allocated for the speech treatment, compared to 2 hours per session for physical therapy and occupational therapy. The treatment activities were presented in 5 steps, which were (1) breathing exercises, pitch control, and nonspeech oral motor exercises, (2) articulation/prosody training, (3) prosody (singing) training, (4) long sentence vocalization training, and (5) checking

speech recognition using voice to text programs. Per the authors, nonspeech oral motor exercises were used to increase muscle tone, however this is a controversial clinical practice with little evidence in dysarthria, especially the progressive dysarthrias (Kent, 2015). “Long sentence vocalization training” focused on breathing in syntactically appropriate parts of a sentence in accordance with the rhythm of the Japanese language. The authors found that participants improved on oral diadochokinesis and maximum phonation time tasks; however, improvements were noted to speech-related quality of life as demonstrated by the shortened version of the Voice Handicap Index (VHI-10). It should be noted that the authors did not include outcome measures related to connected speech such as intelligibility or naturalness ratings. While improvements to oral diadochokinesis and maximum phonation time could indicate a possible improvement in conversation, there is no data within this study to support that idea.

A study conducted by Lowit and colleagues (2020), inspired by the work of Vogel, tested the feasibility and acceptability of using the framework of Lee Silverman Voice Treatment (LSVT LOUD) with people with progressive ataxias. Nineteen participants completed assessment and treatment sessions remotely via *Skype*. There were 4 assessment sessions occurring before treatment, during treatment, and after treatment where participants completed vowel prolongation, reading of a passage, and a 1-minute monologue about any topic. The timeline of treatment followed the LSVT-X format, which is an extended version of LSVT, so treatment was administered across two 50–60-minute (depending on participant fatigue) sessions per week over an 8-week period. Treatment sessions were carried out by speech-language therapists with LSVT LOUD training, who followed the LSVT LOUD protocol with a focus on intelligibility and naturalness. Outcome measures focused on speech (intelligibility, naturalness, and duration of vowel prolongation), psychosocial impact, communication participation, and fatigue. Intelligibility and naturalness were evaluated by a reading task; listeners rated samples using direct magnitude estimation. Listeners were also asked to rate samples of participants’ spoken monologues and were blinded to the assessment session. Improvements in patient-perceived outcomes were reported for psychosocial domains. Vowel prolongation showed statistically significant improvements. However, intelligibility and naturalness showed no significant changes. The authors postulate this was due to adherence issues, most notably with the 15 participants that had fallen ill or taken a holiday during the study, which led to a pause in treatment, then resuming treatment once they had recovered. Participants noted high

acceptability of both the actual treatment, and the remote administration of treatment via *Skype*.

A follow-up study conducted by Lowit and colleagues (2023) tested the feasibility of a novel treatment approach called ClearSpeechTogether with individuals with progressive ataxia. Inclusion in the study required participants to have a diagnosis of mild to moderate ataxic dysarthria, and the ability to complete all sessions remotely via Zoom. Nine participants completed the study, including the 2-week pre-treatment assessment phase, 6-week treatment phase, and 8-week post-treatment assessment phase. All assessments were completed by an author that was not involved with treatment. Level of fatigue and impact on daily activities was measured using the Fatigue Impact Scale (FIS). Other outcome measures were based on the ICF model, including participants' communication at the impairment, activity, and participation level. Information on impairment was gathered by measuring maximum phonation time and vocal quality. Speech measures, accounting for activity level, included connected speech samples via a reading task and a spoken monologue. These connected speech samples were used to measure intelligibility via Direct Magnitude Estimation. Lastly, participation was measured by having participants complete the Communication Participation Item Bank (CPIB).

Treatment focused on the concepts of LOUD and CLEAR, adopted from the LSVT program. Overall loudness is not typically a concern for people with ataxia; however, the cue LOUD was maintained and changed to represent effective vocal use without strain. CLEAR was added to represent overarticulation to increase intelligibility. After a period of one-on-one therapy with an SLP to familiarize the participants with the concepts of LOUD and CLEAR at the single word level, the participants engaged in group therapy to use the principles they learned in a controlled social environment. Participants were encouraged to give each other constructive feedback, which provided support to others and allowed for the development of self-monitoring skills. The authors found that using the principles of ClearSpeechTogether increased participants' intelligibility ratings overall; however, the individual variability influenced statistical significance. Vocal strain, confidence, and communication participation also improved overall, and participants had a positive view of the study based on qualitative interviews.

In sum, studies of ataxic dysarthria have employed a variety of treatment approaches with inconsistent impact on impairment- and activity-level outcomes, particularly when assessing outcomes during the maintenance period. Supplementing individual therapy sessions with group therapy has led to positive experiences and participation outcomes. In addition, evidence of the

feasibility of providing ataxic dysarthria treatment via telerehabilitation, while nascent, seems to be promising.

The clear speech approach

There are numerous strategies which have been implemented to encourage the production of clearer speech. These strategies include asking speakers to overenunciate (Lam & Tjaden, 2013), speak clearly (Tjaden et al., 2014; Whitfield & Goberman, 2014), and speak as if conversing with someone who is hard of hearing (Ferguson & Kewley-Port, 2007; Tjaden et al., 2014). Collectively, these strategies are referred to as variants of clear speech strategies. Clear speech strategies have been shown to be effective across dysarthria types, but most notably for hypokinetic dysarthria in speakers with Parkinson's disease (Stipancic et al., 2022) and have been shown to improve speech-related quality of life (Park et al., 2016; Whelan et al., 2022).

The magnitude of intelligibility benefit varies across clear speech strategies for speakers with dysarthria. In particular, the cue to overenunciate tends to result in greater improvement to intelligibility compared to “speak clearly” and “hard of hearing” cues for typical speakers (Lam & Tjaden, 2013) as well as speakers with dysarthria secondary to Parkinson's disease (PD) and multiple sclerosis (MS) (Stipancic et al., 2022). In a related study, speakers with mild dysarthria from PD and MS had similar intelligibility gains with “clear” and “loud” strategies, but not “slow”. At present, it is uncertain which clear speech strategy would be most beneficial for speakers with ataxia, however, the strongest evidence to date supports the overenunciation strategy.

While clear speech strategies contribute to increased intelligibility, they can also be effortful to maintain. In speakers with PD and MS, the “overenunciation” and “hard of hearing” strategies were found to be more effortful than the “speak clearly” strategy (Stipancic et al., 2022). Extended practice to habituate the speech strategies, or selective use of the strategies, may mitigate level of effort. For example, speaker education may be beneficial regarding when and where to use the speech strategies, and in what situations it may be appropriate to take breaks if the strategies feel too effortful or fatiguing (i.e., speaking with a familiar communication partner).

In 2016, Park and colleagues conducted a treatment study using “*Be Clear*” with eight adults with non-progressive dysarthria from stroke and traumatic brain injury. Their approach combined the clear speech strategies of overarticulation and a slow rate of speech with the

intensive treatment schedule of LSVT LOUD (4 times per week for 4 weeks). Assessments were conducted prior to treatment, immediately post-treatment, and 1-3 months post-treatment, and included speech intelligibility and the Dysarthria Impact Profile (DIP) for everyday outcome measures. After treatment, speech intelligibility at the sentence level significantly increased. Moreover, blinded paired comparison ratings showed improvements of ease of understanding. Additionally, communication partner ratings reflected significantly improved intelligibility and overall communicative function post-treatment. This suggests that rate reduction may play a role in improved speech intelligibility when used along with the clear speech strategy of overarticulation.

Whelan and colleagues conducted a similar study in 2022, following a very similar methodology to Park, except all assessments and treatments were done via telerehabilitation. Fifteen participants with non-progressive dysarthria due to an acquired brain injury were recruited to the study. The clear speech strategies used in treatment were overarticulation and increased speaking volume. Paired comparison ratings showed that samples from post-treatment and follow-up assessments were rated as easier to understand than pre-treatment samples. Results from feasibility measures showed a high level of participant satisfaction with online treatment, with most stating that online treatment felt effective, convenient, and comfortable. The authors also analyzed the relationship between rate reduction and speech intelligibility (percent sentence intelligible) using the Assessment of Intelligibility of Dysarthric Speech (ASSIDS) and found that speech rate decreased significantly at the post-treatment and follow-up time points using the clear speech strategies in treatment. Thus, treatment involving clear speech strategies has shown promising results when broadly applied to speakers with non-progressive dysarthria and feasibility when delivered either in-person or via telerehabilitation (Park et al., 2016; Whelan et al., 2022)

Clear speech and ataxic dysarthria

In the treatment studies of ataxic dysarthria described above, the speech strategies of “loud” and “clear” were generally beneficial for select speakers. The strategy of “clear” was used to represent overarticulation (Lowit et al., 2023). Given the primary challenge with incoordination, the use of the overarticulation strategy should benefit speakers with ataxic dysarthria and would likely naturally lead to rate reduction (Lam et al., 2012) which is often

beneficial for speakers with ataxic dysarthria (Duffy, 2020). Improvements from an overarticulation strategy would most likely center on intelligibility but could potentially have a detrimental impact on naturalness (Gutz et al., 2023). Rate reduction is an important and effective strategy for ataxic dysarthria (Duffy, 2020) as it can potentially mitigate the influence of incoordination and dysmetria and contribute to improved speech breathing patterns (Yorkston et al., 2007). Overall, the clear speech strategies of overarticulation and rate reduction have been found to increase intelligibility in dysarthric speakers (Park et al., 2016; Whelan et al., 2022) and are anticipated to be beneficial for speakers with ataxic dysarthria (Duffy, 2020).

Implementation of clear speech strategies via video conferencing tools, such as Zoom and Skype, has been shown to have high acceptability among participants (Lowit et al., 2020, 2023; (Whelan et al., 2022). The proposed pilot study will be conducted via Zoom and will build on the methodology of Lowit and colleagues (2020; 2023), Park and colleagues (2016), and Whelan and colleagues (2022) using aspects of the *ClearSpeechTogether* and *Be Clear* approaches.

Research Questions

To date, treatment studies of ataxic dysarthria have employed a variety of approaches, including biofeedback (Vogel et al, 2019, 2022), LSVT Loud (Sapir et al., 2003, Lowit et al., 2020), and ClearSpeechTogether (“loud” + “clear”; Lowit et al., 2023). Treatments with a focus on loudness (e.g., Lowit et al., 2020) resulted in limited changes to intelligibility and naturalness in speakers with ataxia, whereas a focus on clear speech/overarticulation and self-monitoring tended to have more positive treatment outcomes. Thus, successful treatment components from the extant literature (e.g., promoting self-monitoring, focusing on overarticulation, implementing individual and group therapy, administering treatment remotely) were paired with positive findings from the broader dysarthria treatment literature on clear speech strategies to create the current treatment approach. The intent of this pilot study was to determine if particular clear speech strategies are beneficial for adults with ataxic dysarthria when provided remotely in an individual and group treatment format.

The following research questions were addressed in this study:

What are the effects of the proposed modified “Be Clear” treatment on:

- a) blinded perceptual ratings of articulatory precision and naturalness
- b) transcription intelligibility per the Sentence Intelligibility Test (SIT) blinded to time point
- c) overall communication and psychosocial benefits per the Communication Participation Item Bank (CPIB) and Dysarthria Impact Profile (DIP), immediately post-treatment and 1-month post-treatment?

It was hypothesized that there would be a significant improvement in blinded perceptual ratings of articulatory precision from baseline to the immediate and 1-month maintenance phases.

Naturalness, on the other hand, was not anticipated to change significantly from baseline as the focus of the treatment is not on prosodic characteristics such as intonation or stress patterning.

Additionally, it was hypothesized that improvements to transcription intelligibility would meet the minimally clinically important difference of 7% improvement (Stipancic et al., 2024) and would be greater immediately post-treatment than at the 1-month maintenance period.

Communication participation restrictions and the psychosocial impact of dysarthria were hypothesized to attenuate post-treatment (immediate and 1-month maintenance).

METHODS

PHASE 1

Speakers

Two participants were recruited via flyer advertisements to regional speech-language pathologists, clinics, and support groups. Inclusionary criteria were:

- 1) A diagnosis of ataxic dysarthria of moderate perceived severity¹
- 2) Sufficient cognition, vision, and hearing to allow participation in the treatment
- 3) Age ≥ 18 years
- 4) Fluent in English
- 5) Stimulable for clear speech during the initial screening
- 6) Access to a computer with the ability to use Zoom
- 7) Access to a quiet environment with little to no background noise
- 8) A reliable internet connection.

Exclusionary criteria were:

- 1) Presence of ataxia < 1 year. A minimum symptom duration requirement helps to ensure an accurate diagnosis as some conditions causing ataxia can be transient or resolve on their own, and it also allows a better sense of the daily life impact of chronic dysarthria and ataxia.
- 2) Presence of other speech, language, or voice disorder, including a mixed dysarthria where another dysarthria is equal to or more prominent than the ataxic dysarthria.
- 3) Presence of neurological condition beyond the cause of the ataxia
- 4) Scheduling constraints that would preclude weekly participation in the protocol.

Speaker Protocol

Screening

All participants were screened via an initial phone call to discuss the generalities of the study and to simultaneously determine the presence and severity of dysarthria via expert judgment (KAS).

¹ Given the heterogeneity of ataxic dysarthria, recruitment for this study focused on speakers from the predominant articulatory inaccuracy (“instability”) subgroup (Spencer & France, 2016; Duffy, 2020) as treatment strategies were best aligned with the speech challenges of this group.

If the participant was deemed to have ataxic dysarthria of at least moderate severity, they were contacted by the investigator (AO) to arrange an initial Zoom meeting to review questions pertaining to the inclusionary and exclusionary criteria of the study (Appendix A) and the planned logistics for the study, as well as to determine internet capability. If the participant met the criteria, the consent form was reviewed. Upon verbal consent to proceed with the study, a follow-up email was sent with a link to the consent form (provided on DocuSign). The initial baseline session was scheduled during the Zoom call; participants were emailed with a reminder of the time of the session and the Zoom meeting link the morning of all session dates. Participant involvement in this study lasted 8 weeks with a follow-up assessment 1 month after the conclusion of treatment.

Zoom session logistics

All assessment and treatment sessions were conducted virtually through Zoom. Each session, the clinician opened the virtual Zoom meeting link ten minutes prior to the expected meeting time to check audio and video quality. Zoom settings were consistent across all participants. Audio settings were as follows: (1) Suppress background noise (set to “Low”), (2) Enable “High-fidelity music mode”. Video settings were as follows: (1) Store recordings to the lab server (L:drive), (2) Select “Record a separate audio file of each participant”, (3) Deselect “Display participants’ names in the recording”, and (4) Select “Keep temporary recording files”. Once audio files were securely stored, video files were deleted. Functionality of the remote connection between the clinician and the participant, as well as ideal recording environment (e.g. ability to see shared screens, properly functioning audio and video devices, stable internet connection, and limited background noise) were discussed and determined during the initial Zoom screening session. All assessment sessions were conducted in the lab with recordings stored on the lab server (L: drive). For logistical purposes, if treatment sessions were not conducted in the lab, they were conducted in a quiet environment and secure location outside of the lab; sessions were recorded from a laptop and later transferred to the lab server.

Assessments

Assessments were conducted at 3 timepoints: baseline, immediately post-treatment, and 1 month following the conclusion of treatment. The initial baseline session included an interview about the participants’ daily communication needs, and their hobbies or interests (see Appendix

B) to develop functional, relevant treatment stimuli for each client (see Appendix C for example of stimuli). Outcome measures at each of the 3 timepoints included:

1. The Dysarthria Impact Profile (DIP; Walshe et al., 2009), which is a scale with 48 items that measures the psychosocial impact of dysarthria from the perspective of the speaker.
2. The Communicative Participation Item Bank – General Short Form (CPIB; Baylor et al., 2013), a 10-item questionnaire that focuses on a speaker’s participation in communication during daily life.
3. The Modified Fatigue Impact Scale (MFIS; Fisk et al., 1994), a 21-item questionnaire that measures the impact that fatigue has on the speaker’s quality of life. The MFIS served as a descriptive measure of functioning as well as a control outcome measure, as treatment is not expected to significantly influence overall fatigue.
4. Speech Intelligibility Test (SIT; Yorkston et al., 2007) sentences: 11 sentences (one each from 5 – 15 words) were recorded to obtain the speaker’s sentence-level intelligibility. Beverly and colleagues (2010) determined that predictability of SIT sentences can influence speech intelligibility scores. Thus, the selection of sentences was only drawn from sentences with adequate predictability metrics (less than or equal to 50 percent predictability; Cannito et al., 2012) which applied to 568 out of the 660 SIT sentences.
5. Reading of the Caterpillar passage (Patel et al., 2013) designed for eliciting connected speech samples from speakers with motor speech disorders.
6. Monologue (1 minute maximum) following the prompt, “Tell me how you make your favorite dish” or “Tell me about a memorable vacation.” Participants were asked to speak until the investigator stopped them at the 1-minute mark.

All assessment stimuli were provided by screensharing PowerPoint slides with the participant while the investigator recorded their responses, when indicated, on printed forms. All sessions were audio recorded using the Zoom settings described above (specifically items 4-6 above).

Treatment (modified Be Clear)

Treatment commenced following the baseline data collection and consisted of 50-minute biweekly sessions for 8 weeks (i.e., about 13 hours of treatment). For the first 6 weeks, individual treatment sessions were conducted, and for the last two weeks, the participants joined together for group treatment. The treatment was based primarily on the “Be Clear” approach of

Park and colleagues (2016) as well as aspects of “ClearSpeechTogether” (Lowit et al., 2023). In general, the primary cue was centered on “BE CLEAR,” which represented overenunciation and speech rate reduction (Park et al., 2016); these strategies are suggested to be the most effective in improving intelligibility (Lam & Tjaden, 2013). The terms overarticulation and overenunciation are used interchangeably in this paper to refer to the action of pronouncing words in an exaggerated manner. In treatment, the more digestible term ‘enunciate’ was consistently used to help solidify the concept. Speech rate reduction was primarily accomplished via use of phrasing. Speakers practiced using the strategies with stimuli of increasing length and complexity.

The specific treatment approach and schedule are summarized below.

Week 1: The first **introductory session** included rapport building, general discussion of the BE CLEAR strategy, and identification of strategy use in pre-recorded videos of reading passages. The videos were < 30 seconds in duration and conveyed a typical speaker reading the Rainbow passage (Fairbanks, 1960) with either regular speech or the BE CLEAR strategy. Two typical speakers were recorded for a total of four videos. After watching the videos, the participant was asked to identify in which video the speaker sounded clearer, then identify what strategies they observed the speaker using. This process, based on Lowit et al. (2023), was intended to familiarize the speaker with the strategies being used in treatment. The participant then had the opportunity to try the BE CLEAR strategy with *knowledge of performance* (KP) feedback (e.g., try opening your mouth more; try to break the sentence down in smaller chunks). A discussion followed about the challenge of changing how we speak, and how it would take consistent practice, starting with phrases/sentences and working our way up to conversation. The second session during Week 1 followed the treatment outlined below for Weeks 2-6.

Weeks 2–6: Individual treatment sessions focused on perceptual discrimination and intensive practice. The first part of the session focused on identification of the BE CLEAR strategy by having the participant listen to audio recorded segments from their previous treatment session (functional speech tasks) and asking them to identify when they used the clear speech strategies and when they did not. The use of previously successful trials simultaneously reinforces expected performance competence, which is known to enhance motor learning (Wulf & Lewthwaite, 2016; Haley et al., 2019). The participants were also verbally prompted to rate their

speech from the recorded segments on a 10-point scale (1 = completely unclear speech, 10 = clear speech; Park et al., 2016).

The second part of the session focused on practicing the BE CLEAR strategy using relevant speech tasks, such as saying functional phrases, making service requests, and more complex communication tasks such as reading, picture description, responding to questions, or conversation (see Table 1). Practice stimuli were as relevant as possible for each client based on information gleaned from the interview. Progression to, and choice of, the relatively complex communication tasks were based on participant success with strategy implementation. Frequent KP feedback was given initially. Support was faded (to less frequent, *knowledge of results (KR)* feedback) to facilitate the development of the participant's self-evaluation skills as they became more familiar with the BE CLEAR strategy and required less prompting to be successful with the strategies.

Homework was given to the participants to encourage maintenance of use of the BE CLEAR strategy. Speakers were recommended to complete daily home practice for about 15 minutes between scheduled sessions. Stimuli for homework were provided to the participants via email after each session, comprised of functional/service phrases that they worked on in the session. The clients were provided with a log that they could use to keep track of what they practiced and for how long.

Week 7–8: The speakers with ataxic dysarthria engaged in **group treatment** to practice implementation of the BE CLEAR strategy in a more naturalistic environment. Although the investigator was present to guide the conversation and activities (see Table 1), participants were the main contributors to feedback on each other's speech during the group sessions (Lowit et al., 2023). For group sessions, homework shifted to focus on functional speech tasks, such as using strategies in a spontaneous conversation with a conversation partner.

Table 1. Components of the modified Be Clear treatment protocol.

Phase	Components	Tasks	Time
Introduction (1 st session)	Identification	Recognition of BE CLEAR concepts in video recordings of typical speakers. Initial shaping of BE CLEAR targets	50 min
Individual treatment sessions	Perceptual discrimination	Identifying the presence or absence of BE CLEAR strategy in audio segments of participant's own speech	10 min
	Practice	Functional phrases (10 phrases, 5 repetitions each, minimum)	10 min
		Service requests (10 requests, 5 repetitions each, minimum)	10 min
		Functional speech task(s) • reading • picture description • answering questions • conversation	15 min
		Discussion of homework tasks	5 min
Group treatment sessions	Practice	Functional speech task(s) • answering open-ended questions • discussing short, relevant news/pop culture segments • conversation	50 min

Note. Based on Park et al., 2016

Data processing

The audio files from the Zoom recordings were uploaded into Audacity, where they were segmented into files for each speaking task (SIT sentences, Caterpillar passage, monologue) and labeled according to assessment time point. For the monologue, a 30-35 second clip was extracted that followed standard convention (i.e., devoid of proper nouns, low frequency words, formulaic expressions, and specialty vocabulary; Sidtis et al., 2012) and maintained grammatical correctness. Three research assistants, blinded to data collection timepoints, transcribed the SIT sentences to determine average transcription intelligibility.

PHASE 2

Listeners

Ten Speech-Language Pathology graduate students from the University of Washington were recruited. Inclusion criteria were self-reported hearing within normal limits and completion of a graduate course on motor speech disorders.

Listener protocol

Participants were asked to complete paired comparison ratings using pairs of audio files from the monologue recordings. All audio files pairs were grouped by speaker. Listeners were blinded to the time point from which the audio files were recorded: pre-treatment, post-treatment and 1-month maintenance. Audio files were randomly presented to each listener using Gorilla Experiment Builder in the following combinations: (1) pre-treatment vs. post-treatment, (2) post-treatment vs. pre-treatment, (3) post-treatment vs. follow-up, (4) follow-up vs. post-treatment, (5) pre-treatment vs. follow-up, (6) follow-up vs pre-treatment. Thus, each listener was asked to judge 12 pairings (6 comparison conditions x 2 speakers). As a metric of intra-rater reliability, listeners were evaluated for their consistency in judging the same samples (e.g., pre-treatment vs post-treatment, and post-treatment vs pre-treatment). For each pairing, listeners were asked to determine (a) which sample was easier to understand and (b) which sample was more natural (see Figure 1). Understandability was defined as “the clarity with which someone is speaking; that is how intelligible they are”, and naturalness was defined as “the speaker's prosody, such as speech rate, rhythm, intonation, and stress patterns”. Listeners were provided with an audio

sample before rating the speakers' audio clips to adjust the volume on the computer to a level that was comfortable and audible to them.

Prior to beginning the listening task, the listeners were provided with the following instructions, based on Park et al., 2016:

“You are going to hear 12 pairs of speech samples and will rate them twice. In total, you will conduct 24 ratings. You will notice that the speech samples repeat. Each speech sample will be about 30 seconds long. You will be deciding which speech sample, the first or the second, is more understandable/precise and which is more natural sounding. Please click "1" if the first sample is easier to understand (or more natural) or click "2" if the second sample is easier to understand (or more natural). If you do not think there is any difference between the two samples, click "same." You are only ever comparing two speech samples with each other. Do not compare one speech pairing to any previous or future speech pairings that you hear. Listen to each pair of speech samples with a “fresh” ear. Please only repeat each sample one time, if desired.”

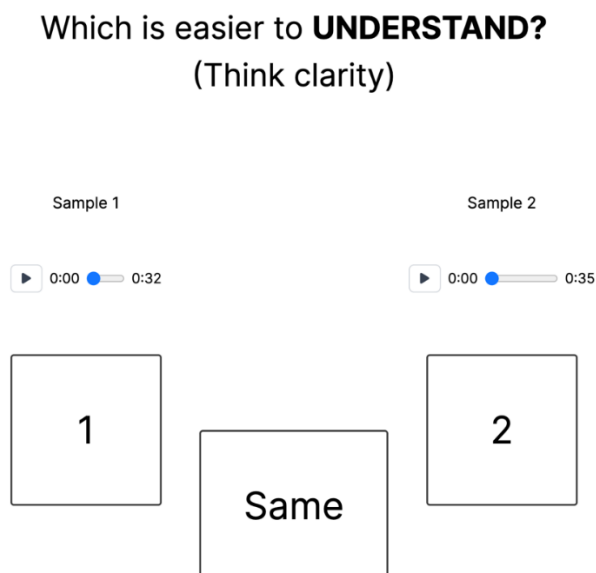


Figure 1. *Screenshot of listener rating screen.*

RESULTS

Participants (Speakers)

Fifteen participants were considered for study inclusion with the goal of recruiting two speakers with moderate severity of ataxic dysarthria. Based on a telephone conversation (KAS) thirteen speakers were excluded for: mild dysarthria (n=8), mixed dysarthria (n=2), or dysarthria characterized by the inflexibility subtype (Spencer et al., 2022) including a slow rate of speech that lessened candidacy for the current treatment (n=3). The two remaining speakers were deemed eligible and are described below (see also Table 2).

Speaker 1 (S1) is a 24-year-old man with spinocerebellar ataxia type 2 (SCA 2) which was diagnosed at age 16. His ataxic dysarthria is characterized by irregular articulatory errors, reduced variations in pitch, equalized stress, prolonged phonemes, and occasional telescoping of syllables. His primary ataxia symptoms include tremors and unstable gait. S1 previously received speech therapy for “over a year” at an outpatient clinic and reported that treatment focused on the use of an alphabet pacing board.

Speaker 2 (S2) is a 64-year-old woman with spinocerebellar ataxia type 6 (SCA 6), which was diagnosed at age 57. Her ataxic dysarthria is characterized by irregular articulatory errors, telescoping, excessive loudness variability, and disorganized speech breathing patterns. Primary ataxia symptoms include impaired balance and fine motor skills. S2 reported that she previously received speech therapy services via teletherapy for “about a year or two.”

Table 2. Demographic and Clinical Characteristics of Participants with Ataxic Dysarthria.

	Speaker 1	Speaker 2
Age (years)	24	64
Sex	Male	Female
Diagnosis	Spinocerebellar ataxia type 2 (SCA 2)	Spinocerebellar ataxia type 6 (SCA 6)
Time post SCA diagnosis	8 years	7 years
Time post dysarthria onset (approximate)	2 years	2 years
Dysarthria severity	Moderate	Moderate

Participants (Listeners)

Ten graduate students (3 first-year students and 7 second-year students) from the Speech and Hearing Science program at the University of Washington were recruited. All had completed a course in Motor Speech Disorders and had self-reported hearing within typical limits. All listeners were fluent in English.

Modified Be Clear Treatment

Adherence

The planned treatment schedule was two 50-minute sessions twice a week for 8 weeks (i.e., 12 individual sessions and 4 group sessions) for 16 total sessions. For the actual treatment schedule, an introductory session was added in the first week, resulting in 17 total sessions. S1 did not attend one group session, so the “group” session became an extra individual session for S2. S2 completed the modified Be Clear program as intended and attended 100% of the sessions. Thus, in total, S1 attended 13 individual sessions and 3 group sessions (16 total), and S2 attended 14 individual sessions and 3 group sessions (17 total).

Paired Comparison Ratings (Research question 1a)

Segments from the speaker monologues were used for the listener rating task. Segments were 34.3 seconds on average (range 32-35 seconds); extraction followed the guidelines of Sidtis et al., 2012. The speech segments represented pre-treatment (time 1), post-treatment (time 2), and 1-month maintenance (time 3). Paired comparisons reflected every possible combination (e.g., time 1 vs. time 2, time 2 vs. time 1; time 1 vs. time 3, time 3 vs. time 1; time 2 vs. time 3, time 3 vs. time 2) for a total of 12 speech samples (6 comparisons x 2 speakers). For each speech sample, listeners were asked to rate which audio clip in the pairing was easier to understand and which was more natural, or if there was no difference between the audio clips (see Figure 1); thus, each listener made 24 judgments (12 speech samples x 2 ratings). Speech segment pairings were presented in a randomized order, and listeners were blinded to the time points.

The figures below show listener preferences for each time point pairing. Data reflect the 10 listeners rating each pairing twice (e.g. pre-treatment vs post-treatment and post-treatment vs. pre-treatment) for a total of 20 pairings/ratings. Therefore, a score of 20 would mean that each of the ten listeners preferred one condition (e.g., post-treatment) for both pairings. As can be seen in

Figure 2, listeners preferred the post-treatment condition for S1 more favorably relative to pre-treatment, particularly for intelligibility. For S2, listeners rated intelligibility relatively equally between the two time points (9 votes for pre-treatment, 8 for post-treatment, with 3 votes for no difference). Naturalness was overwhelmingly considered better pre-treatment with 14 out of the 20 possible votes.

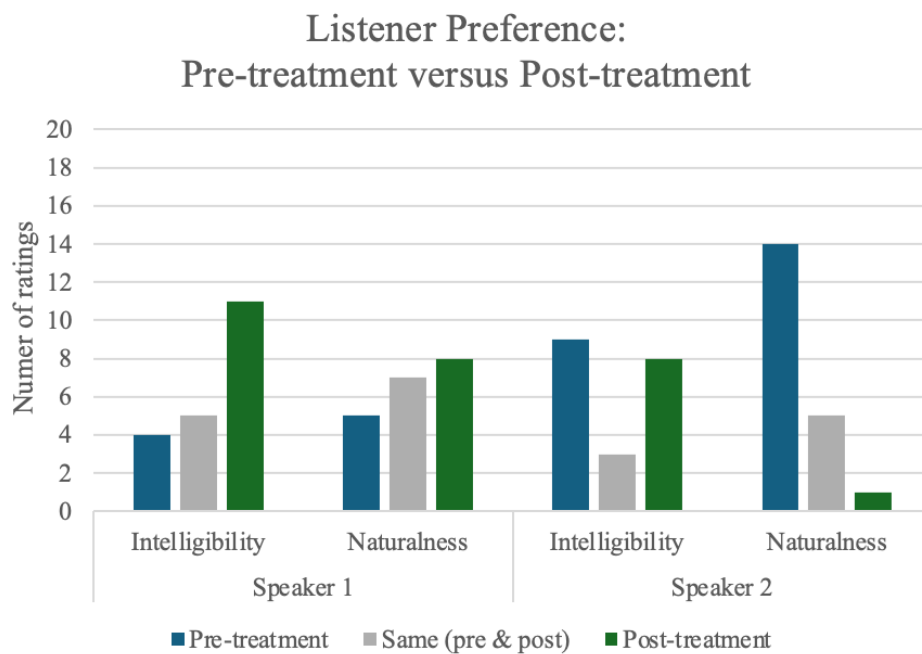


Figure 2. *Frequency counts for pre-treatment vs. post-treatment ratings of intelligibility and naturalness for both speakers.*

For the pre-treatment vs. 1-month maintenance comparison (Figure 3), listeners were largely in agreement that S1's intelligibility was better pre-treatment; however, naturalness was rated better for the 1-month maintenance assessment. For S2, both intelligibility and naturalness were rated more positively for the 1-month maintenance time point relative to the pre-treatment time point.

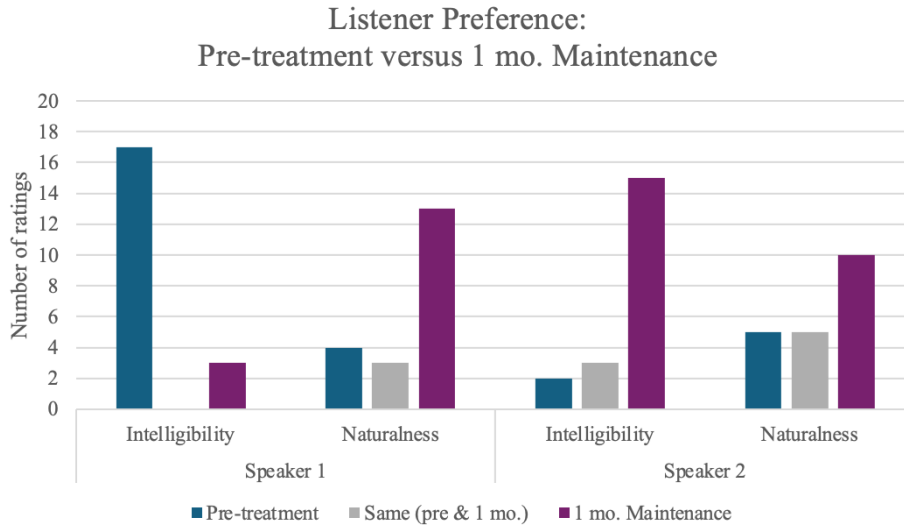


Figure 3. Frequency counts for pre-treatment vs. 1-month maintenance ratings of intelligibility and naturalness for both speakers.

Finally, for the post-treatment versus 1-month maintenance pairing (Figure 4), listeners favored the post-treatment speech sample for S1 for both intelligibility and naturalness. The reverse was true for S2 where listeners strongly favored the 1-month maintenance condition for S2.

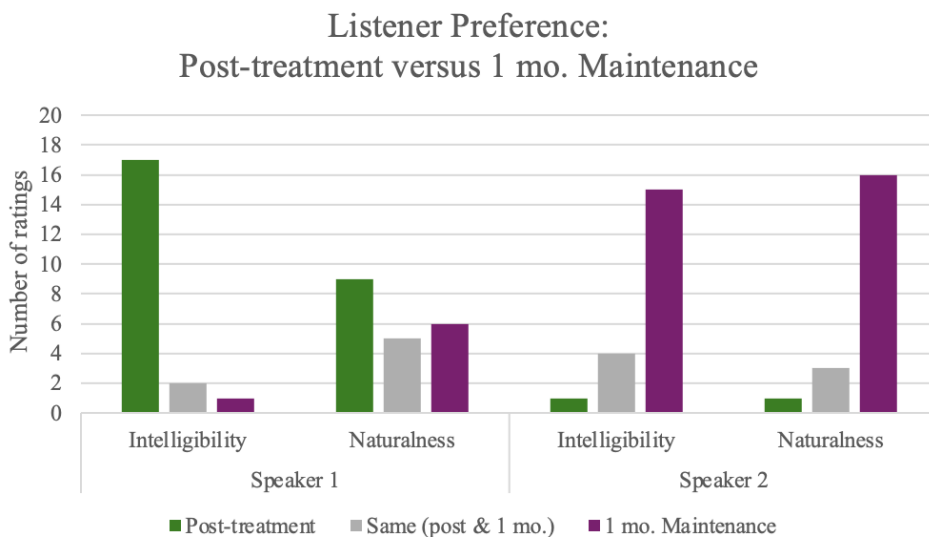


Figure 4. Frequency counts for post-treatment vs. 1-month maintenance ratings of intelligibility and naturalness for both speakers.

Listener preferences across pooled conditions (e.g., the ‘votes’ for pre-treatment when compared to post-treatment *and* 1-month maintenance) are reflected in Figure 5 below. Collectively, listeners rated the post-treatment time point better for S1’s intelligibility, while post-treatment and 1-month maintenance were preferred equally (43% vs 48%) for naturalness. For S2, listeners preferred the 1-month maintenance time point for both intelligibility and naturalness.

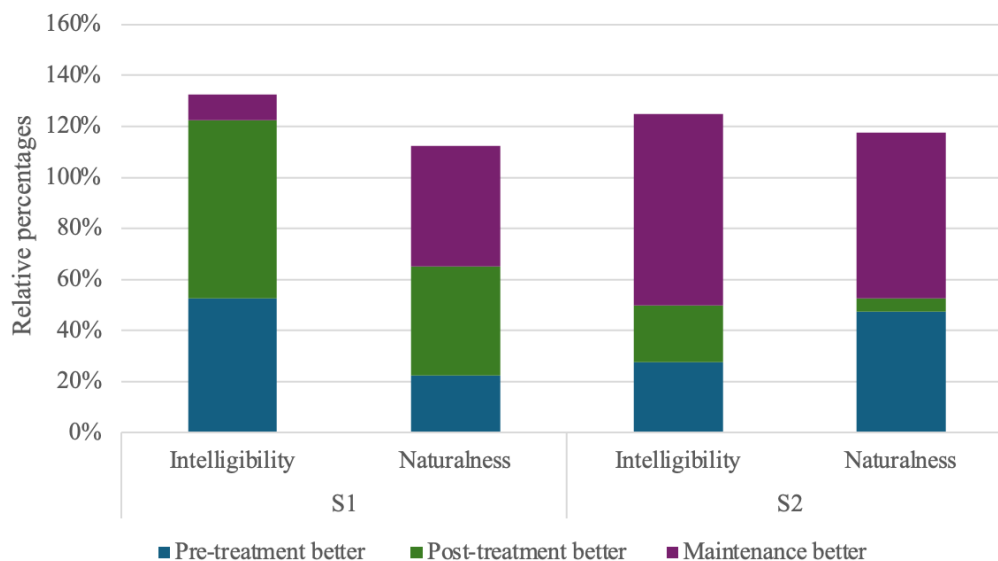


Figure 5. Overall listener preferences for intelligibility and naturalness pooled across all paired comparisons.

Intra-Rater Reliability

Intra-rater reliability was assessed across 10 raters based on repeated presentation of 100% of pairings (e.g., pre vs post and post vs pre). The reliability coefficients ranged from 0.33 to 0.92, with an average of 0.63 (SD = 0.17), indicating overall moderate to substantial agreement (McHugh, 2012). The majority of raters demonstrated moderate (0.41–0.60) to substantial (0.61–0.80) reliability, with two raters achieving almost perfect agreement (≥ 0.81). One rater fell below acceptable reliability standards; however, outcomes did not change appreciably with removal of this rater.

Outcome Measures

Outcome measures related to communication and psychosocial functioning were administered pre-treatment, immediately post-treatment, and at the 1-month maintenance time point. Results are summarized in Table 3.

Transcription Intelligibility (Research question 1b)

Intelligibility percentages are based on the average scores of three research assistants transcribing 11 sentences from the Sentence Intelligibility Test (Yorkston et al., 2007). Both speakers demonstrated a pronounced increase in speech intelligibility post-treatment, with continued improvement noted at the 1-month maintenance interval. Specifically, S1 had intelligibility gains of 11.82 percentage points from pre-treatment to post-treatment, and 22.73 points from pre-treatment to 1-month maintenance. Similarly, S2's intelligibility increased by 9.69 points from pre-treatment to post-treatment, and by 14.24 points from pre-treatment to 1-month maintenance.

Communication participation and psychosocial impact (Research question 1c)

Overall, S1 experienced high CPIB scores and relatively high DIP scores, suggesting that his dysarthria has less of a negative impact, and that he perceives the interference of his dysarthria on his communicative participation as minimal. S2, on the other hand, experienced low CPIB scores and low DIP scores, suggesting that her dysarthria has a moderate-severe impact on her life, and that she perceives substantial interference of her dysarthria on her communicative participation (see Figure 6).

With respect to the CPIB, S1 showed an improvement of 5 points (post-treatment) and 3 points (1-month maintenance) relative to pre-treatment. Conversely, S2's post-treatment and 1-month maintenance scores worsened by 4 points relative to pre-treatment. For the DIP, S1 had comparable scores when comparing pre- versus post-treatment, but showed some improvement related to dysarthria impact at the 1-month maintenance interval (12 point increase). S2 had improved DIP scores post-treatment, but a near return to baseline level by the 1-month maintenance interval. The control measure related to fatigue was anticipated to remain relatively stable over the course of 12 weeks. However, for S1, level of fatigue improved, particularly pre-treatment compared to 1-month post. Thus, overall fatigue may have contributed positively to

overall treatment performance. Conversely, S2 experienced worsened fatigue across the evaluation timepoints, which could have negatively impacted treatment performance.

Table 3. Summary of treatment outcome measures.

	Speaker 1			Speaker 2		
	Pre-tx	Post-tx	1-month	Pre-tx	Post-tx	1-month
Mean Intelligibility	68.78%	80.60%	91.51%	74.24%	83.93%	88.48%
Communication Participation Item Bank (CPIB)	24	29	27	7	3	3
Dysarthria Impact Profile (DIP)	194	193	206	126	140	128
Modified Fatigue Impact Scale (MFIS; control measure)	36	32	22	33	35	42

Note: For the CPIB - General Short Form (Baylor et al., 2013), the total score is 30; higher scores are better and reflect less interference with participation. For the Dysarthria Impact Profile (DIP; Walshe et al., 2009), the total score is 225; higher scores are better and reflect less negative impact of dysarthria. For the Modified Fatigue Impact Scale (MFIS; Fisk et al., 1994), the total score is 84; lower scores are better and reflect decreased levels of fatigue.

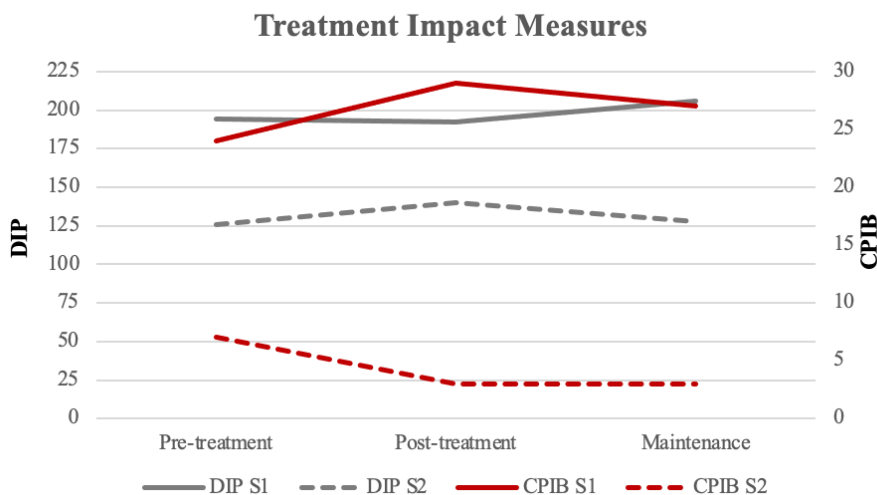


Figure 6. Outcome measures for psychosocial impact per speaker (S1 and S2) on the DIP and CPIB across time points. Higher scores reflect more positive levels of functioning.

DISCUSSION

This pilot study examined the feasibility of a modified Be Clear treatment for two speakers with ataxic dysarthria. The 8-week treatment program was delivered remotely via Zoom, and focused on overarticulation, reduced rate of speech via phrasing, and perceptual discrimination. The speakers had excellent adherence to the treatment schedule and demonstrated improvements across activity-level outcome measures (blinded perceptual ratings and transcription intelligibility), but mixed results for participation-level outcomes (dysarthria impact and interference).

Alignment with hypotheses and extant literature

It was hypothesized that there would be improvement in blinded perceptual ratings of articulatory clarity from baseline to the post-treatment and 1-month maintenance phases. Naturalness, on the other hand, was not anticipated to change significantly from baseline as the focus of the treatment is not on prosodic characteristics such as intonation or stress patterning (see Vogel et al., 2022). Collectively, listeners favored the speech samples post-treatment for both participants. Specifically, for S1, listeners found intelligibility/clarity was best post-treatment, and thought naturalness was equally better for the post-treatment and 1-month maintenance samples. For S2, the listeners showed a strong preference for the 1-month maintenance sample in terms of intelligibility, and a slight preference for this sample relative to pre-treatment for naturalness. Thus, our hypothesis of improvement to clarity of speech was supported as listeners preferred post-treatment and/or 1-month post-treatment speech samples relative to pre-treatment. The positive changes to naturalness, while unexpected, may have been largely influenced by improved phrasing and rate of speech among the speakers (Stocks et al., 2009; Klopfenstein, 2015). Future analysis of prosodic variables such as speech rate, fundamental frequency and loudness variability, and stress use would allow quantification of the discrete acoustic variables influencing the change to naturalness with treatment.

It was also hypothesized that improvements to transcription intelligibility would meet the minimally clinically important difference of 7% improvement (Stipancic et al., 2024) and would be greater immediately post-treatment than at the 1-month maintenance period. This hypothesis was supported, though speakers demonstrated even stronger gains to transcription intelligibility relative to baseline during the 1-month maintenance period. These findings suggest that changes

to intelligibility were more robust than predicted, reflecting a 23 point (S1) and 14 point (S2) increase over pre-treatment levels one month after the conclusion of treatment. Other dysarthria treatment studies using clear speech strategies also reported maintenance of intelligibility gains 1-3 months post treatment, though not to the same extent as the present study. For example, Park et al. (2016) reported a 7 point improvement over baseline to sentence-level intelligibility for their group of 8 speakers with non-progressive dysarthria, while Lowit et al. (2023) reported that 5 of their 8 speakers maintained intelligibility gains long-term.

Finally, it was hypothesized that treatment would attenuate dysarthria impact and interference, as measured by the DIP and the CPIB. This hypothesis was partially supported. S1 viewed his dysarthria as minimally impactful overall. On the DIP, he showed an improvement of 12 points between baseline and the maintenance assessment (no change immediately post-treatment), and on the CPIB, he demonstrated an improvement of 5 points (immediately post treatment) and 3 points (1-month maintenance) relative to baseline. Thus, S1 was conveying more positive perspectives related to his dysarthria and more positive communication participation experiences following treatment. S2, on the other hand, indicated that her dysarthria had a substantial negative impact on her life and interfered considerably with communication. Her perspectives on communication participation, via the CPIB, suggested worsened interference of her dysarthria over the course of treatment. Dysarthria impact (via the DIP) did not change appreciably with treatment. Thus, even with improvement to multiple measures of speech function, psychosocial functioning and communication participation did not parallel these findings. This participant was experiencing unusual life stressors during the treatment study (elaborated below) which may have influenced overall psychosocial findings.

Overall, the results of the current treatment study were comparable to Park et al. (2016), and more positive than the findings of Lowit et al. (2023). Park and colleagues, who used the Be Clear approach with individuals with non-progressive dysarthria, also focused on overarticulation and slow rate of speech. Three of their 8 participants had ataxic dysarthria from a TBI, and another three had a mixed dysarthria with ataxic dysarthria as a component; thus the speech coordination difficulties associated with ataxia were well represented in their study cohort. Park and colleagues implemented an intensive treatment schedule (4 sessions per week for 4 weeks) and included a pre-practice phase focused on enhancing perceptual discrimination of strategy use. They also found significant increases to intelligibility via a paired comparison

rating task as well as improved ratings of ease of understanding. Collectively, the findings from Park et al. (2016) and the present study strengthen the notion that the strategies of overarticulation and slowed rate, combined with intentional building of perceptual discrimination skills, may be beneficial for speakers with ataxic dysarthria.

As discussed, Lowit and colleagues (2023) implemented ClearSpeechTogether via Zoom; this treatment focused on “loud” and “clear” (overarticulation) in nine speakers with progressive ataxia. There were four individual treatment sessions over 2 weeks followed by 20 patient-led group sessions over 4 weeks. While the authors reported improvements to reading intelligibility, there was negligible change to monologue intelligibility, contrary to the present study, perhaps suggesting that additional individual treatment sessions were necessary. However, the extensive (support) group treatment component led to increased communicative participation and confidence among participants.

Potential influences on treatment outcomes

The Modified Fatigue Impact Scale was used as a control measure, with the assumption that fatigue may not change appreciably during the 12-week study period. However, S1 showed an overall improvement of fatigue, particularly pre-treatment to the 1-month post treatment assessment, thus, his speech may have been bolstered by overall perceived improvement to physical functioning. Conversely, S2 reported worsened fatigue throughout the course of the study, which could have had a dampening effect on treatment progress. Overall fatigue has a known influence on speech function and dysarthria (Dias et al., 2024; Makashay et al., 2016), thus the interaction between speech functioning and fatigue should be further explored.

In terms of overall participation and engagement with the treatment program, Speaker 1 demonstrated good engagement with the treatment protocol, though he seemed to have limited insight into his intelligibility. This was primarily shown through his reactions to the perceptual discrimination tasks at the beginning of each session, where he would occasionally report that he was using the rate reduction strategy when he was not, according to the clinician’s judgment. He reported practicing strategies at home around once a week with the provided homework stimuli for 15 minutes.

Speaker 2 demonstrated great engagement with the treatment protocol and strong insight into her intelligibility. She reported that she knew that certain sounds were more difficult for her to make clear, and that she focused on using the overarticulation strategy when she knew those specific sounds were coming up in a word. She reported practicing strategies at home around three times a week for variable amounts of time in conversation with friends or family. Speaker 2 disclosed personal circumstances that occurred in the middle of the treatment period that added external stressors which may have affected her overall perspective on her dysarthria and communication. The stressors shared by S2 led to a decrease in social participation due to lack of access to activities and other social gatherings she would have typically participated in.

Limitations and future directions

Limitations for this study included small sample size and condensed timeline of the treatment period. A small sample size may mean that the results are not indicative of how the treatment program may affect speech intelligibility and psychosocial outcome measures for a larger group of people with ataxic dysarthria across various severity levels. Additionally, despite the provision of a homework log, neither participant adhered to a consistent home practice schedule. It is possible that better adherence to a home practice schedule, especially during the 1-month break between the post-treatment assessment and the 1-month maintenance assessment, could have increased overall carryover of the clear speech strategies.

Future studies should consider extending the group component of the treatment. Generally, group treatment sessions were reported to be helpful by both speakers. They mentioned being able to hear someone else with ataxic dysarthria using the strategies reinforced their own need to use the strategies in their own speech. S2 had reported that she “felt less alone” after the group sessions. Despite this, the condensed timeline of the study did not allow for the speakers to become comfortable enough to provide feedback to each other without clinician prompting. Given a longer timeline or an increased number of group sessions, it is possible that speakers would feel comfortable enough to provide feedback to each other without as much clinician guidance.

Additionally, it could be beneficial to use multiple speech samples from each assessment period for the listener rating task to better represent the speakers’ speech at different time points. Researchers should consider options for home practice, such as combining the stimuli handout

with the homework log, to encourage adherence to a consistent home practice schedule. Given the relatively wide range of intra-rater reliability, future researchers should consider implementing listener training and/or listener calibration to improve overall rater reliability. This could involve training listeners' ears to the audible difference between what an investigator is looking for in terms of changes to intelligibility as opposed to naturalness. Lastly, the treatment program should be further operationalized to encourage consistent clinical implementation. Ideally, treatment fidelity measures would be incorporated into the treatment program to manually document and assess treatment implementation, ensuring consistency and quality of treatment delivery.

CONCLUSION

This pilot study examined the effects of a modified Be Clear treatment program on intelligibility and naturalness with two individuals with ataxic dysarthria from SCA. Findings indicate that an 8-week, remotely delivered speech intervention focused on overarticulation and rate control via phrasing can be an effective clinical intervention for people with ataxic dysarthria. Positive findings warrant future investigation of this approach with a larger and more diverse sample.

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Appendix A: Inclusionary/Exclusionary Screening

Participant #:

Date:

Date of birth:

1. What is your official diagnosis related to cerebellar disease? When were you given this diagnosis?
2. What are your primary symptoms?
3. How long have you had difficulty with your speech? Describe your speech.
4. Did you ever receive speech therapy services for your speech difficulty? Did you ever have a speech problem that wasn't related to your cerebellar disease?
5. Have you ever had a stroke, a traumatic brain injury, or any other neurologic disease or condition beyond cerebellar disease?
6. Do you have significant difficulty seeing or reading things that are within your reach, even when using corrective lenses?
7. Do you have significant difficulty hearing things? For example, do you have to ask people to repeat what they said, or do people often tell you the TV is too loud?
8. Is your schedule open enough for several sessions per week for the months of x and y?
Are you able to take these calls in an area that has little to no background noise?

___ Generally intact cognition (e.g., responding appropriately to questions; able to maintain focus on conversation)?

___ Fluent in English?

Appendix B: Daily Communication Questions

Participant #:

Date:

1. What is a typical day like for you?
2. What do you do for fun? What kind of hobbies do you have?
3. Who are the people that you communicate with most frequently? Are your conversations with them successful?
4. What is your biggest challenge when it comes to communication or being understood? Are there any particularly difficult communication situations?
5. What is most important for you to be able to communicate about?

Appendix C: Practice Stimuli Examples

Functional phrases

1. How are you?
2. I'm doing well, thank you.
3. I'm going to see my friends later.
4. I finished the book I was reading.
5. Can you tell me where to find the bathroom?
6. Please do not interrupt me.
7. When is our next session?

Service requests

1. Please close the door.
2. Can you repeat that?
3. Could you help me with this?
4. When are we having dinner?
5. Could I have a glass of water?
6. Please hold this for a second.
7. Where is the produce section?

Reading passage

Have you ever heard the sound of a hummingbird? They make a buzzing noise when they fly. They make this noise because they beat their wings so fast. They beat their wings up to 80 times a second. All that flapping makes a lot of noise. That's why we call them hummingbirds. Hummingbirds fly in a unique way. They move their wings so fast that they can hover. This means that they can stay in one spot in the middle of the air, like a helicopter. Sometimes they fly or hover upside down. They are the only bird that flies backwards. Hummingbirds are small. One type, called the bee hummingbird, is the smallest bird in the world. Bee hummingbirds weigh less than a penny.

Open-ended prompts for conversation

1. If you had to eat one food for the rest of your life, what would it be and why?
2. If animals could talk, which one do you think would have the most interesting stories?
3. Do you prefer mornings or nights? Why?
4. What is your favorite childhood memory and why?
5. Do you have any pets? Tell me about them.
6. What is a hobby you have always wanted to try? Why?
7. Tell me about your favorite childhood memory.

Example picture for picture description task

