

Consideration of the listener in the assessment and treatment of dysarthria

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<ABSTRACT>

Traditionally, speech production deficits have been the focus of clinical practice and research in dysarthria. However, recent research has begun to examine the role of the listener in communication interaction. This article provides an overview of perceptual processing theory relevant to dysarthria. In addition, it discusses the relationship of current theoretical models of speech perception to the assessment and treatment of dysarthria. Finally, it provides insight into how this information may inform current clinical practices and future research in the field.

Dysarthria

Dysarthria refers to a group of disorders that result from disturbances in the neuromuscular control of speech production. When occurring in isolation, it is associated with impaired motoric speech activity in the presence of normal cognitive-linguistic activity. Dysarthria is a common consequence of acquired neurological impairments including stroke, neurodegenerative disease, and brain injury. While it may affect individuals of any age, dysarthria is commonly exhibited by older adults. Conservative estimates indicate that approximately 20-30% of people will exhibit dysarthria post-stroke (Warlow et al., 2000) or following brain injury (Theodoros, Murdoch, & Goozee, 2001). Furthermore, 50-89% of individuals with Parkinson's disease (Hartelius & Svensson, 1994) and the majority of individuals with motor neurone disease (Saunders, Walsh, & Smith, 1981) will exhibit significant dysarthria with disease progression. With consideration to the ageing populations evidenced in developed nations, the number of cases of dysarthria seen by speech pathologists will only increase.

Dysarthria is characterised by deficits to the speed, strength, range, timing or accuracy of the speech movements. It may affect one or more of the motor speech subsystems including: respiration, phonation, articulation, prosody, and resonance. The resultant speech disorder is characterised by deficits in both the segmental (e.g., phoneme distortions, substitutions) and

suprasegmental (e.g., monotone, monopitch) features of speech production. Across all dysarthria types, speech intelligibility is affected to some degree. It ranges in severity from mild, with increased attention required by the listener to understand speech, through to profound disorder and unintelligible speech. Regardless of severity, the reduced ability to communicate effectively has detrimental effects on the social, family, and vocational life of the individual and their whanau¹ (Theodoros et al., 2001). The presence of dysarthria can result in significant isolation for the individual affected (Hartelius & Svensson, 1994) and has been reported as one of the most distressing symptoms of neurologic disease (Duffy, 2005).

The Role of the Listener in Assessment and Rehabilitation

Central to speech pathologists diagnosis and treatment of dysarthria is the concept of *speech intelligibility*. Intelligibility refers to how well a person's speech is understood by a listener. Traditionally, intelligibility deficits have been considered in relation to the speech disorder of the person with dysarthria. On this basis, much of what is known of the nature of speech deficits in dysarthria, and its treatment, has focused on the production aspects of the disorder (e.g., McAuliffe, Ward, & Murdoch, 2006; Wang, Kent, Kent, Duffy, & Thomas, 2009). However, the speech signal of the person with dysarthria forms only one component of intelligibility; the environment in which communication takes place and the listener's background knowledge and perceptual strategies also play a significant role (Liss, 2007).

On this basis, research has begun to explore the contribution of the listener to speech intelligibility in dysarthria. Studies have focused on listener comprehension of deviant speech (Hustad & Beukelman, 2002), consistency of scoring paradigms utilised by listeners (Hustad, 2006), listener strategies to understand dysarthric speech (Klasner & Yorkston, 2005), the effect of speech supplementation strategies on listener attitudes (Hanson, Beukelman, Fager, & Ullman, 2004) and the effects of listener familiarity or experience with dysarthric speech in explaining variations in listener performance (DePaul & Kent, 2000; Liss, Spitzer, Caviness, & Adler, 2002).

A significant body of literature exists in the field of *speech perception* with various models attempting to account for listeners' comprehension of running speech (See Liss, 2007, for a review). Interestingly, very few studies have examined the ability of the listener to decipher the disordered speech signal of dysarthria, or used theoretical models of speech perception to explain results, even though the aptitude of the listener and their ability to comprehend² the disordered speech is crucial to communication success. The potential benefit of this body of research to the improvement of existing therapy techniques and the development of new strategies remains underdeveloped. The remainder of this review will focus on the application of speech processing literature and theory to the clinical domain of dysarthria.

Dysarthria and Theoretical Models of Speech Perception

Research has identified several cognitive perceptual processes essential to the comprehension of a connected speech signal. These include: lexical segmentation, lexical competition, and lexical

¹ Whanau (pronounced 'far-no') is a Maori word, used commonly in New Zealand, meaning immediate and extended family.

² We recognise that a recent study has drawn distinctions between the terms 'comprehension' and 'intelligibility' (Hustad, 2008). For the purposes of this paper, the terms 'comprehend' and 'comprehension' are used to mean 'decipher'.

activation. In brief, these perceptual processes enable the listener to segment a continuous speech stream into individual words, to access the lexical items that may match these targets, and to finally select the most appropriate word for the spoken utterance. Word meanings are then accessed, and comprehension of the utterance occurs in context. Liss (2007) hypothesised that the segmental and suprasegmental deficits exhibited by speakers with dysarthria may result in interference with the fundamental speech perception processes of lexical segmentation, competition, and activation. Impaired comprehension of message targets (or reduced intelligibility) is the resultant outcome.

Support for this theoretical position was demonstrated by Liss, Spitzer, Caviness, Adler, and Edwards (1998) in their study of 70 young healthy listeners' transcription responses to the speech of individuals with Parkinson's disease (PD) and moderate hypokinetic dysarthria. Liss et al. reported that the suprasegmental deficit of reduced syllable strength (i.e., monopitch and monoloudness) exhibited by individuals with hypokinetic dysarthria had a negative effect on the listener's ability to successfully undertake lexical segmentation, a process thought to be strongly reliant upon the alternating strong-weak syllabic pattern of English (see Cutler & Norris, 1988). As a result, the listeners' ability to comprehend the disordered speech signal was compromised. In a follow-up study that compared listeners' responses ($n=60$) to hypokinetic and ataxic dysarthric speech of moderate severity (Liss, Spitzer, Caviness, Adler, & Edwards, 2000), it was demonstrated that listeners exhibited even greater difficulty employing their use of syllable stress patterning for successful lexical segmentation during perception of ataxic dysarthric speech.

Overall, the findings indicate that salient deviant features of dysarthric speech may differentially affect listeners' ability to employ their perceptual processes during attempts to decipher a spoken message. The insightful nature of these results highlights the need for further research in this field. Further to the work of Liss and colleagues (1998; 2000), it is possible that research investigating speaker-listener interaction, within a framework of speech perception theory, may uncover promising new approaches to the assessment and treatment of dysarthria. Conceptually, we propose three primary areas in which further research may inform the development of assessment and treatment plans for dysarthria. These are discussed in turn below.

Behavioural Intervention Techniques and Speech Perception Theory

In general, behavioural intervention techniques are undertaken with the intention of enhancing the quality of the speech signal and, in turn, improving the ability of the listener to comprehend the speaker's intended message. Intervention techniques take a variety of forms, though three primary strategies appear commonly in the clinical literature: increased vocal loudness, reduced speech rate, and modifying intonation (stress) patterns. To date, research investigating the success or otherwise of these techniques has focused primarily upon speech production changes. For example, Ramig and colleagues (2001) demonstrated, using the Lee Silverman Voice Treatment programme, that the use of increased loudness as a facilitative strategy in PD resulted in significant increases in vocal loudness (in decibels) during sustained phonation, reading, and monologue. While speaker-based dependent variables are important clinical outcomes measures, it could be argued that for speakers with reduced intelligibility, the ultimate outcome of treatment success is an improvement in the listener's ability to understand the speaker. Thus far, only a limited number of studies have examined how these intervention techniques result in concurrent changes to listener ratings of intelligibility (see Wenke, Theodoros, & Cornwell, 2008).

To our knowledge only one study has explicitly examined the effect of commonly used treatment strategies upon listener ratings of intelligibility. Tjaden and Wilding (2004) recorded 27 individuals with dysarthria associated with PD and multiple sclerosis (MS) under conditions of “habitual”, “loud”, and “slow” speech. Ten naive listeners rated intelligibility using a direct magnitude estimation³ paradigm. Results of the study indicated that for speakers with MS, intelligibility was highest in the habitual condition. In contrast, the group with PD exhibited higher intelligibility in the loud condition relative to the slow and habitual conditions.

The findings of Tjaden and Wilding (2004) highlight the possibility that behavioural treatment strategies may differentially affect listener processing. However, this area remains unexplored. It is clearly of interest to determine whether segmental or suprasegmental changes in speech production, resulting from traditional intervention techniques, facilitate or inhibit listeners’ ability to apply typical perceptual processing rules to understand the spoken message (Liss, 2007). For example, why does increased loudness appear to facilitate listener comprehension of speech associated with PD? Secondly, how do other commonly used strategies affect speech comprehension? With converging evidence from production and perception, the theoretical bases for the selection of treatment targets would be strengthened.

While research in this area is forthcoming, clinically, awareness of the potential effects of specific intervention techniques upon communication partners’ perceptual processing strategies is important. When choosing intervention techniques, consideration could be given to determine which types of strategies facilitate improved comprehension on behalf of the speakers’ primary communication partners. This could be trialled during treatment sessions as a form of “stimulability” testing. Furthermore, perceptual processing deficits of communication partners (e.g., resulting from hearing loss, memory problems, central auditory processing deficits) may also be considered in the development of treatment plans.

The Communication Environment and Speech Perception

For the majority of clients, speech intervention focuses concurrently upon learning and implementing behavioural strategies (i.e., improving intelligibility) and optimising communication effectiveness (i.e., improving comprehensibility). If communication effectiveness is the intended goal of treatment, cueing strategies and environmental modifications are employed with the aim of improving communication in everyday settings (Hustad, 1999). When implementing such strategies, two questions may arise: (1) how does the individual with dysarthria modify their speech when confronted with difficult communication environments and (2) how do everyday communication environments affect listeners perceptual processing of dysarthric speech? Clinically, these questions are of paramount importance when consideration is given to the difference between the quiet clinical environment and the noisy, distracting everyday environments in which much communication between speaker and listener occurs.

Research has shown that noise adversely affects speech intelligibility, for normal speakers, under various listening conditions (Bronkhorst & Plomp, 1992; Danhauer & Leppler, 1979; Van Engen & Bradlow, 2007). Furthermore, increased cognitive effort is required by listeners when speech processing occurs in noisy conditions (Larsby, Hallgren, Lyxell, & Arlinger, 2005) and semantic, linguistic and prosodic knowledge must be recruited to atone for

³ An intelligibility scaling procedure used commonly in motor speech disorders research.

what can no longer be perceived within the signal (Pichora-Fuller, 2003). For older adults, which dysarthria affects most often, the challenges posed by everyday communication environments are even greater. While primarily due to peripheral hearing mechanism decline, central auditory processing abilities and cognition also appear to play significant roles (See CHABA, 1988).

Research is yet to determine if, or how, listener processing of normal and dysarthric speech differs in everyday listening environments. However, preliminary research has suggested differences may exist (McAuliffe, Good, O'Beirne, & LaPointe, 2008). While further research is required, steps can be undertaken clinically to consider the communication environment. Firstly, observation of clients communicating in their everyday settings will provide an indication of general communicative effectiveness. Rating scales such as the Communicative Effectiveness Survey (see Hustad, 1999) may be completed to determine which communication strategies may provide the greatest benefit. Secondly, distracters within the communication environment can be identified and potentially minimised. Finally, observation of the communication environment will provide a clear indication of which behavioural treatment strategies may be of use to individual clients and their communication partners.

Perceptual Learning and Dysarthria

The term *perceptual learning* is used to describe the effect whereby exposure to a specific signal alters a listener's perceptual processes during subsequent encounters with that signal. Research has demonstrated that a listener's perception of speech that is initially difficult to understand, can improve significantly with exposure to the signal (Norris, McQueen, & Cutler, 2003). For example, when a listener first encounters a speaker with an unfamiliar foreign accent, they may find it difficult to understand. However, with repeated conversations with that speaker (i.e., exposure), the listener can become better able to comprehend the speech.

Recently, it has been proposed that perceptual learning effects may be one avenue to explore in the development of new intervention techniques in dysarthria (Liss, 2007). Such intervention would aim to improve a listener's ability to comprehend a neurologically disordered speech signal. This listener-targeted treatment would not replace traditional behavioural intervention; rather, would serve as an adjunct to speaker-oriented programmes. In cases where the speech signal is so severely impaired that direct speaker-based intervention would be of little benefit (e.g., motor neurone disease), interventions targeting the listener may provide a new method of improving communication interaction. This could be particularly relevant for those individuals who exhibit co-occurring physical, cognitive, and/or memory deficits, all of which may inhibit new learning, the generalisation of treatment techniques, and/or the use of speech devices.

Currently, the nature of perceptual learning effects is not well understood in dysarthria. Some studies have demonstrated a perceptual benefit with prior exposure to the dysarthric speech signal (e.g., D'Innocenzo, Tjaden, & Greenman, 2007; Liss et al., 2002), while others have failed to find a beneficial effect associated with prior exposure (e.g., Garcia & Cannito, 1996). Closer examination of these studies reveals significant methodological differences among the studies which, in addition to the limited number of studies conducted, may account for the conflicting results observed. A considerable body of literature exists in the wider field of perceptual learning. To date, these principles have not been applied or tested in the clinical domain of dysarthria. Research of this kind is required to provide a foundational basis for the potential development of listener-assisted or listener-based rehabilitation techniques.

Clinically, the potential effects of experience with the speech of an individual with dysarthria are of relevance when selecting outcome measures. If pre- and post-treatment speech rating scales or intelligibility tests are undertaken by the assessing and treating therapist, the effects of perceptual learning will likely result in artificial inflation of post-treatment scores. Therefore, it is imperative that non-treating therapists undertake pre- and post-treatment rating scales. Furthermore, additional outcome measures by familiar listeners (i.e., spouse, friends etc) may be useful to determine whether treatment effects noted by unfamiliar listeners (e.g. non-treating therapists) are similar to those of regular communication partners. Such measures will significantly improve the validity of outcome measures for the management of dysarthria.

Conclusions

Speech production impairments form an important component in the assessment and treatment of dysarthria. However, clinical practice and research is also beginning to consider dysarthria management from the standpoint of speech perception; that is, how and why a communication partner fails to comprehend what is said by the speaker. Further research based on theories of perceptual processing is required to strengthen the rationale for existing treatment techniques and may also provide avenues for the development of additional or alternative treatments in dysarthria.

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