# Consideration of the listener in the assessment and treatment of dysarthria

Megan J. McAuliffe, Stephanie A. Borrie, P. Virginia Good, and Louise E. Hughes

<insert photos>

KEYWORDS
DYSARTHRIA
LISTENER
SPEECH PERCEPTION
COMMUNICATIVE EFFECTIVENESS
TREATMENT
PERCEPTUAL LEARNING

**<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 whanau[1] (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 comprehend[2] 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 speakers 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 estimation[3] 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.



## Acknowledgements

Funding support from the New Zealand Neurological Foundation (Grant 0827-PG), Health Research Council of New Zealand (Grant HRC09/251), University of Canterbury Doctoral Scholarship (Ms Borrie), and University of Canterbury Summer Scholarship Scheme (Ms Good & Ms Hughes) is gratefully acknowledged.

## References

Bronkhorst, A. W., & Plomp, R. (1992). Effect of multiple speechlike maskers on binaural speech recognition in normal and impaired hearing. *Journal of the Acoustical Society of America, 92*(6), 3132-3139.

Committee on Hearing and Bioacoustics and Biomechanics (CHABA). (1988). Speech understanding and aging. *Journal of the Acoustical Society of America, 83*, 859–895.

Cutler, A., & Norris, D. (1988). The role of strong syllables in segmentation for lexical access. *Journal of Experimental Psychology: Human Perception and Performance, 14*(1), 113-121.

D'Innocenzo, J., Tjaden, K., & Greenman, G. (2007). Intelligibility in dysarthria: Effects of listener familiarity and speaking condition. *Clinical Linguistics and Phonetics, 20*(9), 659–675.

Danhauer, J., & Leppler, J. (1979). Effects of four noise competitors on the California consonant test. *Journal of Speech and Hearing Disorders, 44*, 354-362.

DePaul, R., & Kent, R. D. (2000). A longitudinal case study of ALS: Effects of listener familiarity and proficiency on intelligibility judgments. *American Journal of Speech-Language Pathology, 9*, 230-240.

Duffy, J. R. (2005). *Motor speech disorders: Substrates, differential diagnosis, and management* (2nd ed.). St. Louis, MS: Elsevier Mosby.

Garcia, J. M., & Cannito, M. P. (1996). Top down influences on the intelligibility of a dysarthric speaker: Addition of natural gestures and situational context. In D. Robin, K. M. Yorkston & D. R. Beukelman (Eds.), *Disorders of Motor Speech*. Baltimore, MD: Paul H. Brookes.

Hanson, E. K., Beukelman, D. R., Fager, S., & Ullman, C. (2004). Listener attitudes toward speech supplementation strategies used by speakers with dysarthria. *Journal of Medical Speech-Language Pathology, 12*(4), 161-166.

Hartelius, L., & Svensson, P. (1994). Speech and swallowing symptoms associated with Parkinson's disease and multiple sclerosis: a survey. *Folia Phoniatrica et Logopaedica, 46*(1), 9-17.

Hustad, K. C. (1999). Optimizing communicative effectiveness: Bringing it together. In K. M. Yorkston, D. R. Beukelman, E. A. Strand & K. R. Bell (Eds.), *Management of motor speech disorders in children and adults*. Austin, TX: Pro-Ed.

Hustad, K. C. (2006). A closer look at transcription intelligibility for speakers with dysarthria: Evaluation of scoring paradigms and linguistic errors made by listeners. *American Journal of Speech-Language Pathology, 15*, 268-277.

Hustad, K. C. (2008). The relationship between listener comprehension and intelligibility scores for speakers with dysarthria. *Journal of Speech, Language, and Hearing Research, 51*(3), 562-573.

Hustad, K. C., & Beukelman, D. R. (2002). Listener comprehension of severely dysarthric speech: Effects of linguistic cues and stimulus cohesion. *Journal of Speech, Language, and Hearing Research, 45*, 545-558.

Klasner, E. R., & Yorkston, K. M. (2005). Speech intelligibility in ALS and HD dysarthria: The everyday listener's perspective. *Journal of Medical Speech-Language Pathology, 13*(2).

Larsby, B., Hallgren, M., Lyxell, B., & Arlinger, S. (2005). Cognitive performance and perceived effort in speech processing tasks: Effects of different noise backgrounds in normal-hearing and hearing-impaired subjects. *International Journal of Audiology, 44*, 131-143.

Liss, J. M. (2007). The role of speech perception in motor speech disorders. In G. Weismer (Ed.), *Motor speech disorders: Essays for Ray Kent* (pp. 195-231). San Diego, CA: Plural.

Liss, J. M., Spitzer, S., Caviness, J. N., & Adler, C. (2002). The effects of familiarization on intelligibility and lexical segmentation in hypokinetic and ataxic dysarthria. *Journal of the Acoustical Society of America, 112*, 3022-3030.

Liss, J. M., Spitzer, S., Caviness, J. N., Adler, C., & Edwards, B. (1998). Syllabic strength and lexical boundary decisions in the perception of hypokinetic dysarthric speech. *Journal of the Acoustical Society of America, 104*, 2457-2466.

Liss, J. M., Spitzer, S. M., Caviness, J. N., Adler, C., & Edwards, B. W. (2000). Lexical boundary error analysis in hypokinetic and ataxic dysarthria. *Journal of the Acoustical Society of America, 107*, 3415-3424.

McAuliffe, M. J., Good, P. V., O'Beirne, G., & LaPointe, L. L. (2008). *Influence of auditory distraction upon intelligibility ratings in dysarthria*. Paper presented at the Conference on Motor Speech Disorders.

McAuliffe, M. J., Ward, E. C., & Murdoch, B. E. (2006). Speech production in Parkinson's disease: I. An electropalatographic investigation of tongue-palate contact patterns. *Clinical Linguistics and Phonetics, 20*(1), 1–18.

Norris, D., McQueen, J. M., & Cutler, A. (2003). Perceptual learning in speech. *Cognitive Psychology, 47*, 204-238.

Pichora-Fuller, M. K. (2003). Processing speed and timing in aging adults: psychoacoustics, speech perception, and comprehension. *International Journal of Audiology, 42*, S59-S67.

Ramig, L. O., Sapir, S., Countryman, S., Pawlas, A. A., O'Brien, C., Hoehn, M. M., et al. (2001). Intensive voice treatment (LSVT) for patients with Parkinson's disease: A 2 year follow up. *Journal of Neurology, Neurosurgery, and Psychiatry, 71*, 493-498.

Saunders, C., Walsh, T., & Smith, M. (1981). Hospice care in the motor neuron diseases. In C. Saunders & J. C. Teller (Eds.), *Hospice: The living idea*. Sevenoaks, UK: Edward Arnold Publishers.

Theodoros, D. G., Murdoch, B. E., & Goozee, J. V. (2001). Dysarthria following traumatic brain injury: Incidence, recovery, and perceptual features. In B. E. Murdoch & D. G. Theodoros (Eds.), *Traumatic brain injury: Associated speech, language, and swallowing disorders* (pp. 27-51). San Diego, CA: Singular.

Tjaden, K., & Wilding, G. E. (2004). Rate and loudness manipulations in dysarthria: Acoustic and perceptual findings. *Journal of Speech, Language, and Hearing Research, 47*(766-783).

Van Engen, K. J., & Bradlow, A. R. (2007). Sentence recognition in native- and foreign-language multi-talker background noise. *Journal of the Acoustical Society of America, 121*(1), 519–526.

Wang, Y. T., Kent, R. D., Kent, J. F., Duffy, J. R., & Thomas, J. E. (2009). Acoustic analysis of voice in dysarthria following stroke. *Clinical Linguistics and Phonetics, 23*(5), 335-347.

Warlow, C. P., Dennis, M. S., Van Gijn, J., Hankey, G. J., Sandercock, P. A. G., Bamford, J. G., et al. (2000). *Stroke: A Practical Guide to Management*. Oxford, UK: Blackwell Scientific.

Wenke, R. J., Theodoros, D. G., & Cornwell, P. C. (2008). The short- and long-term effectiveness of the LSVT for dysarthria following TBI and stroke. *Brain Injury, 22*(4), 339–352.

Correspondence to:
**Dr Megan J. McAuliffe**
Department of Communication Disorders
University of Canterbury
Christchurch, New Zealand
phone: +64 3 364-2987 ext. 7075
fax: +64 3 364 2760
email: megan.mcauliffe@canterbury.ac.nz

< Megan McAuliffe is a senior lecturer at the University of Canterbury (UC), New Zealand. She received her PhD from the University of Queensland, Australia. Megan's research

focuses on acquired motor speech disorders, in particular the role of the listener in communication interaction. Megan is an Associate Editor with Evidence-Based Communication Assessment and Intervention, former Editor of the New Zealand Journal of Speech-Language Therapy, and current President of the New Zealand Speech-language Therapists' Association.

>