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Methods of speech therapy treatment for stable dysarthria: A review

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Abstract
The objective of this review is to make treatment techniques published in the literature more easily accessible to clinicians in the field of stable dysarthria. This was achieved by performing a systematic review identifying and describing techniques for the treatment of stable dysarthria which have been the subject of published research. Electronic medical databases Medline, Cinahl and Amed were searched for literature published from 1966 to March 2006 that describe and or evaluate treatment techniques used for stable dysarthria. Of 46 papers found, 23 were included in the systematic review as they included the main concepts of stable dysarthria and treatment/therapy in the abstract. Published dysarthria treatment techniques reviewed are presented according to the parts of the speech system that they address. As the research studies published on stable dysarthria treatment use small numbers of participants and investigate very different treatment techniques, it is not possible to draw conclusions about the efficacy of different techniques. However, the review summarizes different treatment techniques for speech and language therapists to use with stable dysarthria and sign posts them to relevant literature.

Keywords: *Stable dysarthria, treatment techniques, review.*

Introduction

The dysarthrias are a group of motor speech disorders resulting from a disturbance in neuromuscular control. Dysarthrias are among the most commonly presenting communication disorders representing 46.3% of neurogenic communication disorders referred to the speech pathology department of the Mayo Clinic between 1987 and 1990 (Duffey, 1995). Dysarthrias were also found to be one of the largest client groups referred to speech therapy departments in the UK between 1987 and 1995 (Petheram & Enderby, 2001). Despite this, the disorder has received little research attention compared to less common communication disorders such as dysphasia.

Much of the research that has taken place in the field of dysarthria treatment has focused on dysarthria as a symptom of the progressive disorder Parkinson's disease with less attention paid to the longstanding, non-progressive dysarthria often experienced by people with cerebral palsy or following a stroke or traumatic brain injury (Enderby & Emerson, 1995). Dysarthria due to non-progressive conditions such as cerebral palsy, stroke or TBI is often described as stable as it is neither improving nor deteriorating (Yorkston, Beukelman, Strand, & Bell, 1999). Most publications present discussion, expert opinion and single subject experimental designs to evaluate treatment techniques for stable dysarthria. These studies often do not fulfil the Cochrane criteria, and as a result, papers presenting treatment techniques for stable, longstanding dysarthria are rarely the subject of systematic review. For example, in a systematic review of non progressive dysarthria only unconfounded, randomized controlled trials were considered, following the Cochrane criteria (Sellars, Hughes, & Langhorne, 2006). No papers fulfilling these inclusion criteria were found, thus Sellars et al. (2006, p. 8) concluded that ''There is no evidence of the quality required by this review to support or refute the effectiveness of speech and language therapy interventions for dysarthria following non-progressive brain damage''.

Cochrane reviews explore the evidence for and against the effectiveness and appropriateness of treatments (medications, surgery, education, etc.) in specific circumstances and therefore use criteria which exclude study designs which do not demonstrate effectiveness (*The Cochrane Collaboration*, n.d.). Despite a lack of large clinical trials to test whether treatment techniques for stable dysarthria are effective, systematic reviews help to collate information about treatment techniques that have been described

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or studied. For the busy clinician, a review provides one single source of information about treatment techniques available. However, the authors do not attempt critical appraisal of the techniques as the small scale or non-experimental nature of the studies cannot provide evidence of effectiveness. Instead, the primary purpose of this review is to describe treatment techniques found in the literature, hopefully providing a useful balance to the necessarily limited reviews that result from the Cochrane approach. Full details of treatment studies are outside of the scope of a review paper therefore the authors aim to summarize the treatment studies for stable dysarthria in order to offer practising speech and language therapists an overview of the wide range of available treatment techniques. References collated in the review sign post readers to the primary research papers for full details of treatment studies.

Method

The question identified to direct the search for literature on dysarthria treatment was as follows: what speech therapy methods for treatment of stable dysarthria have been described or evaluated? A strategy was designed for use in searching electronic databases, with ''dysarthria'' as the main concept in a keyword search. Boolean operators ''AND'' and ''OR'' were used to combine ''dysarthria'' with each of the alternative terms; ''speech therapy'', ''treatment'', ''intervention'' and ''method''. Electronic databases of medical and paramedical research were searched: Amed, Medline and Cinahl. References were also tracked by hand searching the index to speech and language publications produced since 2002 and references from dysarthria text books. As the published research into dysarthria is known to be limited, electronic databases were searched from 1966 to March 2006 to review the majority of the history of dysarthria treatment. The searches were limited to references published in the English language. The search history from Medline exemplifying the search in detail can be found in the Appendix. The first author selected references for inclusion in the review by reading the abstracts of all the references produced by the search. Papers were included in the review if they contained the main concepts of dysarthria and treatment/therapy on stable populations such as head injury, stroke, and cerebral palsy. The papers fulfilling the criteria for this review detailed a wide variety of treatment strategies studied with different methodological designs, often limited to single case studies or expert opinion. Papers whose main focus was assessment, dysarthria due to progressive aetiologies, or treatment of other speech, language or voice disorders were excluded from the review. Although other review papers will be acknowledged, this paper reviews only primary sources of treatment information.

Results of the literature search

Forty-six papers were identified in the databases with the search concepts. After applying the selection criteria, 23 papers were identified for review. Table I presents a summary of the data extracted from the papers reviewed for the methods of speech therapy used with people with stable dysarthria.

Research into dysarthria treatment and study designs

This search of the literature found just 23 studies published in the international journals about the treatment of dysarthria in people with non-progressive conditions since the 1970s and only eight of these were published since 1996 confirming that it has not been a popular area of research. The majority of the studies used single subject experimental designs or reported and discussed the treatment used with individual cases. Such study designs provide useful information about treatment techniques which have been used with dysarthric speakers; however, they do not allow generalizations to the wider population of dysarthric speakers to be made.

Populations studied with stable dysarthria

Table I shows that the stable dysarthria of people participating in studies resulted from three main aetiologies: cerebro-vascular accidents (CVA), traumatic brain injury (TBI) and cerebral palsy (CP).

Aims of treatment

Table I shows that the common aim of more than half of the studies of treatment reviewed was to improve intelligibility or communication effectiveness as the therapy outcome. The treatments used to achieve this aim include slowing down the rate of speech. This has been achieved by pointing to the first letter of each word on an alphabet chart as it is spoken (Beukelman & Yorkston, 1977); using visual feedback from oscilloscopes on the time it takes to speak a sentence (Yorkston, Hammen, Beukelman, & Traynor, 1990); and presenting words or underlining them slowly on a computer screen (Pilon, McIntosh, & Thaut, 1998). Further details of these treatment methods are described in a later section on rate. Other treatment studies have focused on improving one particular speech parameter. For example, treatment can aim to regain motor control (Gentil, Aucouturier, Delong, & Sambuis, 1994), to increase fundamental frequency modulation (Bougle, Ryalls, & Le Dorze, 1995), or to increase loudness (Solomon, McKee, & Garcia-Barry, 2001). Treatment of single speech parameters also suggest a positive effect on improving intelligibility, including modification of articulation (Ince & Rosenberg, 1973) and decrease in lip tension in spastic dysarthria (Keatly & Wirtz, 1994). Other studies

Table I. A summary of chronic dysarthria treatment literature.

Authors/Treatment Categories	Date	Treatment aim	Treatment type	Study type	Population of study	Key findings
RATE						
Beukelman & Yorkston	1977	Slowing speech rate to increase intelligibility	Rate control with alphabet board	Single subject design (2) comparison of 3 conditions	CVA TBI	Intelligibility increased with use of the alphabet board—for one subject due to decrease rate, for the other due to letter cueing
Berry & Goshorn	1983	Reduce rate of speech	Clinician model with real time visual feedback from an oscilloscope	Single subject design	CVA 6 months post onset ataxic dysarthria	Slowed speech rate and increased intelligibility
Caliguiri & Murray	1983	Increase rate of speech	Visual model of therapist oscilloscope trace and feedback on own production	Single subject design (3)	CVA MS Dysarthria types: ataxic, spastic, mixed	Increase in speech rate and prosody and a decrease in overall severity of speech
Yorkston, Hammen, Beukelman & Traynor	1990	Increase intelligibility	Rate control (using computer modelling)	Single subject (8)	Ataxic and hypokinetic dysarthrias	Metered rate control strategy more effective than rhythmic
Pilon, McIntosh & Thaut	1998	Reduce speech rate to increase intelligibility	3 types of rate control: -singing pacing (copying investigator) -metronome pacing -board pacing	ABACAD single subject design	TBI Spastic-ataxic dysarthria	Pacing increased intelligibility Metronome pacing was most effective
RESONANCE						
Kuehn	1997	Strengthen soft palate	Continuous positive airway pressure (CPAP)	Case examples	2 individuals with TBI	CPAP can exercise the soft palate
OROMOTOR						
Clark	2003	Neuromuscular treatments	Active exercises Passive exercises Application of physical modalities	Theoretical tutorial and expert opinion	Treatments described for people with hypotonicity, hypertonicity and weakness	Empirical support for neuromuscular treatments is lacking
Gentil, Aucouturier, Delong & Sambuis	1994	Regain motor control	EMG biofeedback – real time visual feedback	Discussion	Not specified	Not applicable
ARTICULATION						
Ince & Rosenberg	1973	Modification of articulation to increase intelligibility	Modelling of correct pronunciation, and giving direct feedback ‘clear’ or ‘unclear’	Single subject design (2)	CVA 7 and 9 months post onset	No unclear sentences after 36 sessions of therapy
Robertson	2001	Evaluation of a protocol of therapy to increase intelligibility of speech	Orofacial muscle exercises, DDK rate drills, drills of sound sequences, articulation exercises. 3x per day for ten weeks	Single subject design (8)	CVA	10% increase reflected in intelligibility scores

(*continued*)

Table I. (*Continued*).

Authors/Treatment Categories	Date	Treatment aim	Treatment type	Study type	Population of study	Key findings
PROSODY						
Berry & Goshorn	1983	Reduce intensity	Clinician model with real time visual feedback from an oscilloscope	Single subject design	CVA 6 months post onset ataxic dysarthria	Slowed speech rate and increased intelligibility
Caliguiri & Murray	1983	Increase use of prosody	Visual model of therapist oscilloscope trace and feedback on own production	Single subject design (3)	CVA MS Dysarthria types: ataxic, spastic, mixed	Increase in speech rate and prosody and a decrease in overall severity of speech
Solomon, McKee & Garcia-Barry	2001	Increase loudness	Lee Silverman Voice Therapy with physiotherapy	Case report	TBI	Mixed methods were useful in helping the client to increase volume
Sapir, Spielman, Ramig, Hinds, Countryman & Fox	2003	The effect of Lee Silverman Voice Treatment (LSVT) on ataxic dysarthria	Lee Silverman Voice Treatment	Single subject design	Stable ataxic dysarthria	Short- and long-term improvement gained in phonation, articulation, intelligibility and communication at work
Bougle, Ryalls & Le Dorze	1995	Increase fundamental frequency (f0) modulation (prosody)	Therapist model of f0 and IBM Speech viewer visual feedback	Single subject design (2) Alternating treatments	TBI	Significant improvement in f0. No differences between therapist and speech viewer feedback. Speech viewer provides useful means of f0 measurement
COMPENSATORY STRATEGIES						
Hunter, Pring & Martin	1991	Increase intelligibility	Speaker strategies to aid listener: - visual cues - repetition - initial letter cueing	Single subject design Comparison of 4 conditions	Cerebral Palsy	Strategies help improve communication transfer. Cueing most helpful for speakers with severe dysarthria
Carinski & Rosenbek	1999	Increase intelligibility	Use of Speech Enhancer	Single subject design (2)	Hypokinetic dysarthria	Intelligibility scores increased by 67%—a clinically significant result
Berry & Sanders	1983	Increase intelligibility	Environmental education	Expert opinion	General advice for people with dysarthria	Adjustments to the communication environment can improve communication transfer
TREATMENT PROGRAMMES						
McNamara	1983	Increase speech intelligibility	Programme of treatments including palatal lift for resonance	Case study	CVA	Treatment options are described, the programme only selects practical options

(*continued*)

Table I. (*Continued*).

Authors/Treatment Categories	Date	Treatment aim	Treatment type	Study type	Population of study	Key findings
McHenry & Wilson	1994	Increase communication effectiveness	Programme of treatments including palatal lift for resonance	Case report	TBI	The person with dysarthria is key in accepting or refusing types of treatment
Drummond, Worley & Watson	2003	Description and evaluation of the Dysarthria Treatment Programme (DTP)	Programme of exercises addressing all speech processes	Single subject design (2)	CVA	Significant improvement shown after 7 sessions
Aten	1988	Increase intelligibility	Combination of respiration, phonation, resonance, articulation and prosody treatment	Case report and expert opinion	TBI 2 years post onset, spastic dysarthria	Improvement observed
TREATMENT OF LONGSTANDING DYSARTHRIA						
Enderby & Crow	1990	Not applicable	Not applicable	Retrospective survey of 4 clients	TBI Long term dysarthria	Improvement began up to 2 years post onset
Keatly & Wirtz	1994	Increase intelligibility	Decreased lip tension in single sounds and built up to words	Single subject design	Dystonia	Specific lip tension reduction therapy was more effective than non specific treatment
Simpson, Till & Goff	1988	Increase communication ability	Programme of techniques for 39 months	Longitudinal case study	Severe, long term dysarthria	Small gains from individual techniques combined to produce a significant overall gain

Notes: TBI = traumatic brain injury; CVA = cerebrovascular accident; MS = multiple sclerosis; (number) = number of participants in the study.

report aiming to improve intelligibility using programmes of treatments addressing more than one speech parameter. For example, phonation, resonance, articulation and prosody were all addressed in a treatment programme for a participant with severe flaccid dysarthria (McNamara, 1983). This is further described later in the text, along with examples of other multisystem treatment programmes. Speaker strategies (Hunter, Pring, & Martin, 1991); environmental education (Berry & Sanders, 1983) and use of the Speech Enhancer (Spencer, Yorkston, & Duffey, 2003) are also described as techniques to improve intelligibility.

Techniques used in the treatment of stable dysarthria

Treatment strategies focusing on speech systems, or using treatment programmes to increase overall intelligibility of speech include therapy for respiration, phonation, oro-motor skills and articulation, resonance, prosody, and rate (Robertson & Thomson, 1986). Treatment approaches are either traditional/behavioural, involving teaching the client new skills or compensatory strategies (Swigert, 1997); instrumental, applying modern technology to provide accurate measurements and biofeedback when the clients' practise new skills; or prosthetic approaches, which alter the physical properties of the motor speech system (Murdoch, 1998). All of these approaches are reviewed here. Techniques found in the literature to treat stable dysarthria (Table I) are described and discussed for each speech system.

Speech rate

Slowing speech rate is a frequently used technique for improving the intelligibility of speakers with dysarthria in Table I. An early study by Beukelman and Yorkston (1977) used an alphabet board as an aid to slow speech rate. The two participants in the study pointed to the first letter of each word as they spoke it. This method reduced the speech rate from 39 words per minute (WPM) to 18WPM for one participant and from 86WPM to 28WPM for the other participant. Intelligibility was measured by the number of words identified correctly in a given sample by the listeners. For one participant, the improvement in information transfer shown was found to be due to the visual letter cueing for the listeners, while for the other participant the improvement was shown to be due to the reduced speech rate (Beukelman & Yorkston, 1977).

In line with the findings of Beukelman and Yorkston (1977), an instrumental approach using oscilloscope traces increased speech intelligibility. The goal for the participants was to make the trace continue over more than half of the screen along the horizontal axis by increasing word and pause duration (Berry & Goshorn, 1983; Caliguiri & Murray, 1983).

Further instrumental techniques have been used to pace the speaker by underlining the word or by adding the next word when it is to be spoken. Yorkston, Hammen, Beukelman, and Traynor (1990) used computers to pace the speaker in the following ways:

1. Additive metered – here the computer presented one word then added another at regular intervals for the speaker to say.
2. Additive rhythmic – again the words were presented one at a time, but this time the intervals between presentations reflected those naturally produced when speaking the same material without an aid to slowing speech.
3. Cued metered – here the material to be spoken was all shown on the screen and the computer highlighted the words in turn for the speaker to say at regular intervals.
4. Cued rhythmic – the words were highlighted reflecting the natural rhythms of the spoken material.

Eight single participants participated in this study with nine listeners. Threats to the reliability of judgements of naturalness were reduced by testing the intra-judge reliability. As dysarthric speech is known to deteriorate with fatigue, Yorkston et al. (1990) demonstrated that fatigue did not influence the results with a large sample of sentences (11) and words (110) by comparing the results of the large spoken sample to the results with a smaller sample of spoken words and sentences. Steps to ensure internal validity were taken by blinding the listeners to the conditions and randomizing the order of the conditions listened to (Yorkston et al., 1990).

An explanation for the effect of decreasing speech rate on intelligibility could be that a slow speech rate increases accuracy of the articulators in speech and thus is used as a technique to address articulation (Aten, 1988; McHenry & Wilson, 1994). However, Yorkston et al. (1990) suggested that this is not the case as the listeners in their study were often worse at identifying individual phonemes in slowed speech. They offer an alternative explanation that a reduced speech rate aids the linguistic processing of the listener rather than the speech signal of the speaker (Yorkston et al., 1990).

Investigations that compare strategies to decrease speech rate indicate that they vary in the level of their success. Yorkston et al. (1990) found that the cued metered (underlining words at regular intervals) strategy was the most effective in helping to slow speech rate and did not significantly decrease the naturalness of the clients' speech. This finding can be supported by Pilon et al. (1998) whose pilot study to investigate the effect of pacing techniques on slowing speech indicated that metronome pacing, similar to a metered strategy with one word per beat, was the most effective. Metronome pacing was

compared with singing pacing (copying the investigator, then singing alone) or using a pacing board, tapping a finger from one side to the other as each syllable is spoken. Singing and board pacing varied in their success for different participants.

The results of the pilot study suggest a differential effect of rate control with the severity of dysarthria that requires further investigation with a larger scale study. The pacing techniques increased intelligibility for the more severe participants but decreased the intelligibility of the less severe participant (Pilon et al., 1998).

Resonance

CPAP (continuous positive airway pressure) has been described as a means of exercising the soft palate during speech in two individuals with traumatic brain injury (TBI). The technique provides resistance against which the muscles of velopharyngeal closure must work (Kuehn, 1997). A prosthetic intervention—palatal lift—has also been described for the management of velopharyngeal impairment (VPI). A palatal lift is a rigid acrylic appliance fabricated by a prosthodontist. It consists of a retentive portion that covers the hard palate and fastens to the maxillary teeth by means of wires and a lift portion that extends along the oral surface of the soft palate. Despite being effective, a palatal lift is not always a chosen method of VPI management due to difficulty accessing a prosthodontist, or the client's intolerance of, or choice not to wear it (McNamara, 1983; McHenry & Wilson, 1994).

Oro-motor treatment

Oro-motor exercises are commonly used in programmes of treatment to remediate dysarthria (McNamara, 1983; Robertson, 2001). Clark (2003) describes three types of neuromuscular impairment that can be remediated with oro-motor treatments: Weakness defined as a reduced ability to exert force and may result from damage to the upper motor neurons as in spastic dysarthria or the lower motor neurons as in flaccid dysarthria; hypotonicity identified by reduced resistance to passive stretch resulting from damage to the lower motor neurons as in flaccid dysarthria; hypertonicity identified by increased resistance to passive stretch resulting from damage to upper motor neurons as in spastic dysarthria. Clark (2003) provides a detailed account and discussion of oro-motor treatments which the authors direct readers to for explanations of why different techniques are recommended. The techniques are summarized here. Active exercises focus on strength training whose goals are to increase the tension or force a muscle can produce, to increase endurance, i.e., the amount of force that can be sustained over longer periods of time and to increase power which is the speed at which force is produced. Exercises with low levels of resistance typically increase endurance while high levels of resistance increase strength. Clark (2003) suggests that exercises need to continue to the point of fatigue to achieve transfer. Increasing rate of exercises helps to increase power. These active exercises are recommended for weakness and hypotonicity. For hypertonicity slow stretching is recommended. Passive exercises consist of tapping the belly of the muscle or using quick stretches to increase tone in hypotonicity and slow stretching and deep massage to help muscle relaxation with hypertonicity. Finally Clark (2003) describes application of physical modalities for treatment of the oral musculature. These include applying cold or vibration for disrupted tone (hyper or hypotonicity) and cold or heat for weakness. Despite the wide clinical use of neuromuscular treatments, much controversy still surrounds their use. Strength training is a key issue. Clark (2003) suggests that individuals use only a small proportion of their potential muscular force during speech therefore if tongue strength is reduced to 60% they are still likely to be able to produce the forces necessary for speech production. However, significant power may be necessary to produce the forces at an adequate speed, which may be optimized by strength training, improving articulatory accuracy and intelligibility (Clark, 2003).

Electromyography (EMG) is an instrumental technique that provides objective feedback in real time. The momentary changes in electrical activity that occur when a muscle contracts are recorded with surface electrodes, needle electrodes or hooked wire electrodes placed overlying or next to the muscle of interest. Amplifiers turn the signal into a real time visual display of the muscle activity. The clients can compare their own muscle activity to that of a normal speaker. The technique provides the client with information about a specific component of the speech production system helping to control the specific muscle, a technique directly related to regaining motor control (Gentil et al., 1994).

Articulation

Behavioural and instrumental techniques to encourage improvements in articulation focus on modelling targets, repetition of targets, and feedback on speech performance (Ince & Rosenburg, 1973; Gentil et al., 1994; Robertson, 2001). An early study with the focus of increasing articulation clarity was carried out by Ince and Rosenberg (1973) with two participants post CVA. Key components of the technique were modelling of the sentence to be spoken by a normal speaker and feedback on the sound of the participant's attempt (auditory feedback) with the investigators' judgements of the clarity (judgemental feedback). The participants spoke a sentence and the two investigators independently labelled the attempt as ''clear'' or ''unclear''. One

investigator told the participant ''clear'' or ''unclear'' and played back a recording of the sentence. The other investigator modelled a clear production of the sentence and the participant produced the sentence again. This treatment of two 30 minute sessions per week continued until all the sentences were clear. The number of clear sentences increased as the sessions progressed, with 67 and 72 unclear sentences respectively in session one and no unclear sentences by session 36. Although two listeners were used providing some control for the inter-rater reliability of the clarity judgements, the listeners were also the investigators in this study leading to the potential for bias in their judgements. The judgements were subjective and may have been influenced by familiarity with the participants' speech as the sessions progressed. Such a treatment technique requires further investigation in more controlled studies.

More recently, Robertson (2001) described and evaluated a protocol of oro-facial and articulation exercises with eight participants post CVA. The treatment protocol consisted of 45 minutes of therapy per week for 10 weeks including oro-facial muscle exercises, diadachokinetic (DDK) rates, sound sequences, and articulation exercises from consonant-vowel-consonant combinations to long, complex utterances. Repetition and frequent practice were important to the treatment protocol with recommendations of four sets of five repetitions for each exercise, three times daily. Dysarthria scores were obtained using the Robertson Dysarthria Profile (Robertson, 1982). She reported that all areas specifically targeted for practice showed improvement and intelligibility scores increased by an average of 9.9% and observed that those who did less home practice showed less improvement.

Prosody

Prosody is used to refer to the suprasegmental elements of speech such as pitch, volume, stress and intonation. Instrumental techniques have been used to control volume with the oscilloscope. The visual feedback from the oscilloscope trace can provide a model of the upper and lower limits of the therapist's intensity for the client to try to copy, and for real time visual feedback of their own intensity (Berry & Goshorn, 1983; Caliguiri & Murray, 1983).

A behavioural approach to increasing volume has been detailed by Solomon et al. (2001), combining the use of Lee Silverman Voice Treatment (LSVT) exercises and physiotherapy on the upper chest wall to increase volume in a client with TBI. LSVT is an intensive treatment programme requiring four, 1 hour treatment sessions per week for 4 weeks. The aim is to increase the effort during phonation by frequent encouragement to ''speak loudly'' or to ''shout''. Carryover from sustained vowels to speech is initiated early in treatment and is emphasized as the treatment progresses. Solomon et al. (2001) report on a case where a client was given standard LSVT which increased loudness in treatment but with very little carryover and hence little benefit to speech intelligibility. The technique was used again but for a period of 6 weeks with the addition of respiration exercises and chest physiotherapy. This was continued for an hour per week for a further 10 weeks to help carry over. After this 16-week block of combined treatment, loudness of speech increased on oral reading and monologue and most lung measures were maintained after three months (Solomon et al., 2001).

Improvements in phonation, articulation and intelligibility have also been reported by Sapir et al. (2003) using the LSVT programme. The standard programme of Lee Silverman Voice Treatment was given to an individual participant with stable ataxic dysarthria. She showed short- and long-term improvements not only in the phonatory functions addressed by the programme but also in articulation, intelligibility and overall communication ability at work. This single participant study was well designed with acoustic and perceptual measurements made three times before treatment, twice after, and once at a 9-month follow-up. Acoustic data were collected from a range of speech tasks including sustained ''ah'', reading, picture description, and monologue. A constant microphone distance was ensured for accurate measures of loudness. Perceptual measures of pitch, intonation and articulatory precision were made by 26 student speech and language therapists, blinded to the stage at which the recordings were made. For all perceptual measures the listeners were played a pair of items and asked which was best, or if they were the same. Listeners had 96% intra-judge and 98% inter-judge reliability for intonation and 72% intra-judge and 80% inter-judge reliability for articulation precision ratings (Sapir et al., 2003).

Behavioural/traditional treatment for pitch has been compared with an instrumental approach using the IBM Speech Viewer (*SpeechViewer III*, n.d.). An alternating treatment design with two individual participants was used in which traditional treatment (T1) consisted of the therapist producing a model for the client to reproduce and verbal comments were given as feedback from the therapist. SpeechViewer treatment (T2) gave a visual model for the client to reproduce and visual feedback on the production. T1 and 2 were both presented twice, making 8 weeks in total after which the participants spoke an average of 20 Hz higher. However, there were no significant differences between treatment with or without the visual feedback from the SpeechViewer (Bougle et al., 1995). It would be interesting to replicate this study with a larger number of participants to see whether the use of the Speech Viewer made a difference to other participants. The authors of this paper did note the usefulness of the SpeechViewer in

making objective measurements of fundamental frequency, which were used to compare the two treatment types in this study.

Strategies to reduce the effect of the speech impairment on communication ability

The previous studies described have concentrated on treatment techniques to reduce the speech impairment of the dysarthria by addressing different parameters of speech. Strategies to reduce the effect of the impairment on communication transfer including alternative and augmentative communication strategies (AAC) have been identified. As well as use for rate control, alphabet boards are used for the speaker to point to the first letter of each word. This provided visual cues for the listeners and was shown to increase the number of words correctly identified (Beukelman & Yorkston, 1977).

Speakers often use repetition as a strategy to help information transfer. People with dysarthria are also encouraged to let the listeners have a full view of their face assuming that non verbal communication cues will aid communication transfer (Berry & Sanders, 1983). Hunter et al. (1991) compared these strategies for speakers with dysarthria who had cerebral palsy. Each participant spoke 50 sentences and listeners wrote down the keyword as a measurement of communication transfer. In condition one the listeners only heard the speakers. In condition two the listeners had audio and visual information from a video of the speakers (like a normal face to face communication situation). In condition three the listeners had audio-visual information and sentence repetition. In the fourth condition, the first letter of the keyword was given to the listeners before they heard the sentence.

As suggested for rate control techniques, a differential effect was found for speakers with different severities of dysarthria. For those with moderate dysarthria, all strategies were better than just hearing the speaker, but strategies of repetition and letter cueing were no more helpful to the listeners than just being able to see the speaker. For those with severe dysarthria, the provision of visual information or repetition of the sentence was no more beneficial than just having the auditory signal, but the letter cueing strategy did significantly improve the information transfer. Hunter et al. (1991, p. 172) therefore conclude that, ''therapy should include instructions to utilize strategies most appropriate to the intelligibility level of a client's speech''. The validity of the repetition condition is questionable. In the study the sentences were replayed to the listeners which is not representative of online repetition in which the speaker is likely to attempt to transfer the information successfully to the listener, by speaking more slowly, exaggerating the speech or increasing the volume for example.

Communication can be aided by management of the communication environment, the responsibility of both the speaker and the listeners. Berry and Sanders (1983) illustrated use of environmental education as part of a programme of treatment for a single case whose intelligibility increased from 27 to 82%. The authors recommended setting up the communication situation by setting the scene for the listener with a preparatory carrier phrase, e.g., ''I want to talk about...''. The authors also suggested controlling the effects of noise by turning the radio/television down or off, gaining the listener's eye contact, moving away from the noise source and closer to the listener, and talking slowly and precisely. They recommended sitting in a well lit area, less than 4 feet from the listener, maintaining a posture that enables the listener to see the speaker's face. The authors note the importance of considering the effect of hard walls and floors and dampening excess resonance with carpets and wall coverings (Berry & Sanders, 1983).

The Speech Enhancer is an instrumental technique for improving intelligibility of impaired speech. It is an assistive speech system device developed by Electronic Speech Enhancement, Inc in St Louis, Missouri. It was developed to amplify and clarify disordered speech even in the presence of ambient noise, comparing the incoming signal to a normalized model of speech and altering the model in real time to a best fit approximation of the model. Carinski and Rosenbek (1999) claim that speech intelligibility scores increased by 67% for two speakers with dysarthria when using the Speech Enhancer.

Programmes of treatment

Treating an individual with dysarthria usually involves using a combination of treatment techniques appropriate to the nature of the type and severity of the dysarthria, and in line with the individual's own goals and treatment preferences. The literature search identified case reports where programmes of treatment including a range of treatment techniques and communication strategies have been selected for individual clients. Table II illustrates how a programme of treatment techniques has been assembled to address the dysarthria of specific individuals.

Although these studies are not experimental, they provide an illustration of how techniques are combined to improve the communication of individuals. These case reports highlight practical barriers to using some treatments. For example, identified techniques may be useful in a treatment programme but cannot be used due to lack of resources such as a palatal lift and recordings of airflow and air pressure (McNamara, 1983). The client himself/herself plays a part in deciding which techniques are used, for example making a choice not to wear a palatal lift (McNamara, 1983; McHenry & Wilson, 1994). McHenry and Wilson (1994, p. 372) state:

Table II. Techniques used together to form programs of treatment for individual clients.

Authors	McNamara (1983)	Aten (1988)	McHenry & Wilson (1994)
Client	Severe flaccid dysarthria post CVA, female, age 50 years	Spastic dysarthria 2 years post TBI	Severe dysarthria 9 years post TBI
Respiration techniques	Recordings of airflow and air pressure would have been applicable for biofeedback, however such equipment was not accessible	Elevation of client's arms in a sling Wide elastic band just below rib cage to support the weak abdominal muscles during exhalation	
Phonation techniques	Hypertonic exercises used to strengthen paretic vocal cord	Encourage gentle voicing to avoid activating the threshold for excess stiffness Prolonged vowels, counting, rote recitation, short conversational phrases (in order)	
Resonance techniques	Palatal lift (but client unwilling and no prosthedontist on the staff)	Thermal stimulation (icing) prior to voicing Palatal lift	Palatal lift (client chose not to wear it)
Articulation and orofacial techniques	Neurofacilitation programme to reduce flaccidity (specific exercises not described)	Speak more slowly	Rate reduction by speaking syllable by syllable, using a pacing board
Prosody techniques	Loudness increased using Kay Visipitch to provide visual feedback (Kay Elemetrics, 1979)	Visible and auditory pacing	Stress placement cued by underlining or writing stressed word in capitals
AAC	Letter board, Canon Communicator, Speak 'n' Spell (synthesized speech output), amplifier		
Generalization of techniques			Articulation and prosody techniques practised with short structured responses to personal questions, structured conversation, unstructured conversation with speech therapist and unstructured conversation with an unfamiliar listener in that order

"Consciously or not, individuals with unintelligible speech do a cost-benefit analysis of treatment strategies".

A systematic treatment programme providing speech task stimuli and guidelines for therapists has recently been developed for dysarthria (Drummond, Worley, & Watson, 2003). The Dysarthria Treatment Programme (DTP) was designed to target all speech processes simultaneously during intervention. It contains 18 tasks and 53 activities. The tasks are divided into six non-speech and nine speech tasks. The DTP provides stimuli for the different speech tasks (type, length and complexity) with instructions and expected performance for successful completion. Guidelines are also provided to help the clinician select the type, number and complexity of tasks for specific symptoms. It is not possible to describe 53 activities in detail within the confines of this paper therefore the authors' direct readers to the primary paper for specific information on each activity. The efficacy of the DTP has been initially examined with a longitudinal study of two adults with moderate-severe, non progressive dysarthria. Each participant received the DTP in seven treatment sessions, three times a week for the first 2 weeks and once a week thereafter. Each session was approximately 45 minutes long. Speech and non-speech tasks were alternated in presentation. The medical status of Participant 1 deteriorated, however Participant 2 increased her intelligibility from 53–100% with DTP treatment (Drummond et al., 2003). Unfortunately, the clients in this study were only 2–5 days post-CVA and consequently recovery may have been spontaneous. Further evaluation of the DTP is required using experiments controlled for spontaneous recovery.

Treatment over the course of recovery

Three papers specifically focussed on the potential for improving speech of long standing dysarthria. Keatly and Wirtz (1994) asked "is 20 years too long?" In a well controlled single subject experimental study the authors showed that therapy produced a measurable and lasting improvement in intelligibility for their client. Anecdotal evidence suggested that these changes were of clinical significance to the client as he was reported to attempt to communicate in a wider range of social situations, communicated with greater frequency, used speech more often as his chosen method of communication and his communication attempts were said to be more successful. There is evidence to suggest that providing treatment after a long period of time may be more beneficial in some instances than early treatment. In a retrospective study of long term recovery patterns in four people with severe dysarthria following TBI, few gains were noted in bulbar function in the first 18 months post onset. Despite oral motor treatment being discontinued after 24 months, the most substantial changes in Frenchay Dysarthria Assessment scores were seen in the clients between 24 and 48 months post onset (Enderby & Crow, 1990, p. 535). The authors concluded that "it is possible to speculate that oro-motor therapy should be implemented at a later stage with severely head-injured patients in an attempt to exploit and extend returning function". Simpson, Till, and Goff (1988) reported on the long-term treatment of a client with severe dysarthria secondary to an infarct caused by basilar artery thrombosis. The client was in a coma for 3 weeks and presented a slow pattern of recovery. Alternative communication in the form of an alphabet board and a head pointer was implemented after 4 months and the client was ready for treatment of oro-motor skills after 21 months, leading to articulation practice after 25 months. This is in line with the suggestion that oral/motor therapy would exploit returning function most successfully at a later stage, 24–48 months (Enderby & Crow, 1990). The client studied by Simpson et al. (1998) continued therapy for 3 years with the use of an abdominal binder for respiratory support, a palatal lift to reduce hypernasality and a voice amplifier to increase speech intensity. Simpson et al. (1988, p. 439) report that "modest gains from a number of intervention techniques ultimately worked together to effect a meaningful change in an individual's communication".

Discussion

A range of techniques for the treatment of stable dysarthria have been studied with populations post stroke or with TBI, or those who have longstanding dysarthria with cerebral palsy. The common aim of these treatment techniques is to contribute to increasing intelligibility or communication effectiveness. In addition to traditional/behavioural techniques, instrumental techniques for treatment have been used including oscilloscope traces for rate, pitch and loudness, computer programs to cue rate reduction and the IBM Speech Viewer for treatment of pitch. Treatment techniques have been described for the individual parameters of rate, resonance, oro-motor skills, articulation and prosody. Although the nature of the studies reviewed does not allow generalizations to be made regarding effectiveness of these techniques, it is possible to identify those which have received the most attention in the literature. Slowing speech rate was the most common direct speech intervention reviewed in this paper. Techniques described in earlier papers used alphabet charts to help cue the speakers to use a slower speech rate. Instrumental techniques were published from the 1980s onwards using oscilloscopes and computer technology to provide models of a target speech rate and visual feedback of performance. In the 1990s two studies separately compared a metered rate control cueing strategy to a rhythmic cueing strategy and both indicated that metered rate control is more successful in slowing

speech rate than rhythmic cueing. It has been suggested that rate reduction strategies can work well in increasing intelligibility for people with severe dysarthria but may make speakers with only mild dysarthria less intelligible.

Techniques described for treating resonance were limited to CPAP and the use of the prosthetic palatal lift device. The results of this review did not include material from other review articles as reviews usually consist of primary data. However, the authors feel it is important to discuss information found by other reviews to provide speech and language therapists with a more complete account of dysarthria treatment. The management of velopharyngeal impairment (VPI) specifically in dysarthria has been reviewed by Strand and Sullivan (2001). They found evidence for the use of CPAP as an effective means of exercising the soft palate during speech in two individuals with TBI. In addition to techniques for resonance described by this review, Strand and Sullivan (2001) found evidence to support the use of behavioural techniques such as slowing the speech rate, changing the level of speech effort, monitoring excess nasal airflow using a mirror, nasal flow transducer or nasal anemometer, and increasing the precision of speech by exaggerating articulatory movements. They also described other techniques in common use which expert opinions did not support:

- pushing techniques for clients with spastic dysarthria;
- strengthening exercises such as blowing and sucking;
- tasks that encourage the client to modify the air stream using balls, whistles, candles, fluff, powder, paper, bubbles, straws etc.;
- inhibition techniques such as prolonged icing, pressure to muscle insertion points, slow and irregular stroking and brushing, and desensitization (Strand & Sullivan, 2001).

For further detail and references readers are directed to the paper by Strand and Sullivan (2001).

Oro-motor exercises are commonly used for attempting to strengthen speech musculature in dysarthria treatment and these have been described by Clark (2003). As oro-motor exercises are a popular technique in dysarthria treatment, controlled studies are required to offer support for this technique. Techniques for the treatment of articulation focus on modelling of clear, target pronunciations and regular repetition of articulatory targets (e.g., four sets of five repetitions three times a day). Robertson's (2001) study supports the combination of oro-motor and articulation treatment in improving intelligibility but more studies are required to strengthen the support for treating articulation. Studies illustrating treatment techniques for prosody focus on pitch, volume, stress and intonation. The common feature of these techniques is that they all offer feedback either visually or verbally. Success of the Lee Silverman technique has been reported. This may be due to combinations of goals, verbal encouragement and intensive treatment delivery (four 1 hour treatment sessions per week for 4 weeks).

The literature search used for this review did not produce any references to studies of respiration or phonation for a client group with stable dysarthria. However, studies on techniques for treating respiration and phonation have been considered in other literature reviews. A systematic review by Yorkston et al. (2003) found evidence for the effectiveness of biofeedback in improving respiratory control, including the provision of information to the client about sound pressure levels, abdominal and chest wall movement and the amount of subglottal air pressure. Spencer et al. (2003) presented levels of support for commonly used techniques to treat respiration. In addition to the biofeedback techniques mentioned, there is evidence based support for pushing and pulling techniques and breathing against resistance with a water manometer, blow bottle or resistive mask. Expert opinion supports the use of postural adjustments to improve breath support and externally applied pressure to the abdomen with a hand or an expiratory board or paddle and controlled exhalation tasks. There is no empirical or expert support for the use of blowing balloons, bubbles, feathers, etc., applying ice or electrical stimulation to the diaphragm. Regarding phonation techniques, the systematic review by Spencer et al. (2003) showed empirical support for effortful closure techniques to enhance vocal fold adduction, and easy onset techniques to reduce tension in speech. Expert opinion also supports hard glottal attack, postural adjustments and physical manipulations of the thyroid cartilage to enhance adduction. Muscle relaxation or massage and biofeedback to monitor muscle tension during speech to reduce hyper-adduction are supported by expert opinion (Spencer et al., 2003).

Combinations of these treatment techniques to form programmes tailored to the individual have been described and supported. From the studies of different treatment techniques, key components that may contribute to success can be identified. These include providing models of the targets for the client to aim to achieve, regular repetition of practice stimuli, regular intensive practice/treatment sessions and the provision of feedback on the practice attempts.

Dysarthria can be stable, i.e., neither spontaneously recovering, nor progressively deteriorating, for many years although it is uncommon for treatment to be offered after a year or two at most. This review has identified studies that suggest treatment techniques can be employed with some success with stable dysarthria many years post onset and in the case of TBI, treatment after about 20 months may facilitate further recovery.

A limitation of this review is that it only reported on studies in the published literature. The results may therefore reflect publication bias towards studies with positive findings rather than studies which refute the use of certain techniques. A further obvious limitation is the small number of studies on different treatment techniques and the small numbers of study participants used which do not allow for any conclusions about effectiveness to be drawn. The authors suggest that the content of the paper is clinically significant in that it describes a wide range of treatment techniques available to the practising clinician offering useful management and research pointers. Whilst some techniques have been studied more than others, all techniques require more small exploratory trials in preparation for randomized controlled trials which will offer clinicians information on the effectiveness of dysarthria treatment techniques.

Conclusions

The clinical implications of this review are that there are a wide variety of techniques available to use to treat people with stable dysarthria and that time post onset should not necessarily be a factor in the clinical decision of whether or not to offer treatment to this client group. Further research into treatment for people with stable dysarthria is required in order make generalizations about the effectiveness of the treatment techniques described.

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Appendix

Specific literature search in Medline:

Search term 1: *Dysarthria [classification, diagnosis, rehabilitation, aetiology, therapy] produced 305 references.

Search term 2: *Therapeutics [methods, classification, contraindications, standards, history, trends, instrumentation] produced 750 references.

Search term 3: *rehabilitation/ or *speech therapy/ produced 7822 references.

Search term 4: *Intervention studies produced 115 references.

Search term 5: *Methods [standards, history, instrumentation, methods] did not produce any references.

Results of search terms 2 OR 3 OR 4 were combined to produce 8685 references. This result AND search term 1 were combined resulting in 27 references.

This search method was repeated for Cinahl and Amed databases.