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Evidence for Effectiveness of Treatment of Loudness, Rate, or Prosody in Dysarthria: A Systematic Review

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This systematic review of the literature addresses interventions for dysarthria that focus on the global aspects of speech. The review is part of the development of practice guidelines for the Academy of Neurologic Communication Disorders and Sciences (ANCDS). A search of electronic databases (PsychINFO, MEDLINE, and CINAHL) and hand searches of relevant edited books yielded 51 articles focusing on loudness, rate, prosody, and general instructions. These articles were rated for the strength of evidence they provide for the effectiveness of intervention. Articles were categorized into phases of research and evaluated in terms of the level of participant description, outcome measures, evidence of research control, and findings. The strongest evidence regarding treatment effectiveness is in the area of modification of loudness in individuals with Parkinson's disease who have hypokinetic dysarthria. Directions for future research are provided in the areas of rigor of evidence and its reporting, outcomes, candidacy criteria, and application of principles of motor learning to intervention.

One of the primary goals of speech intervention for speakers with dysarthria is to improve communicative function. At times, this is accomplished by focusing on specific speech subsystems. For example, the management of the velopharyngeal systems is addressed in a previous review (Yorkston et al., 2001b). At other times, the focus of intervention is on the entire process of speech production. Global

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aspects of speech production are those that span the different levels of speech production: respiration, phonation, resonance, and articulation (Dromey & Ramig, 1998). Global aspects also span the time domain and are applied throughout an utterance rather than occurring during a specific gesture (e.g., enhancing bilabial closure), syllable or sound (e.g., production of precise sibilants). Changes in loudness, speaking rate, and prosody are the targets of such intervention programs. The purpose of this systematic review is to *identify the types* and strength of evidence documenting the effectiveness of interventions targeting the global aspects of speech production in speakers with dysarthria.

METHODS

Background

This systematic review is part of the development of practice guidelines for management of dysarthria sponsored by the Academy of Neurologic Communication Disorders and Sciences (ANCDS) and supported in part by ASHA (Office of the VP of Clinical Practices in Speech-Language Pathology, and Steering Committee of Division 2) and by the Department of Veterans Affairs (DVA). Systematic reviews can be viewed as a process of evaluation of evidence from both *research literature* and *expert opinion* with the goal of assisting clinical decisions. The procedures for developing these reviews are described elsewhere (Yorkston et al., 2001a).

The Searches

We searched the following electronic databases: PsycINFO covering 1,300 journals (1967 to Nov. 2004), MEDLINE covering 3,900 journals (1966 to Nov. 2004), and CINAHL covering 600 journals (1982 to Nov. 2004). The initial searches were keywords paired with the term, *dysarthria*, for example, dysarthria and rate, dysarthria and loudness, dysarthria and prosody. In addition to these electronic searches, hand searches of relevant edited books in the area of dysarthria and ancestral searches of extant references (*e.g., studies cited* within an article or chapter) were conducted. From this large search, those citations related to intervention were described, rated, and compiled in a series of Tables of Evidence. Intervention studies were defined as those focusing on treatment of the speech production for at least *one person* with a primary communication diagnosis of *dysarthria*. Thus, articles were excluded that:

1. described the global aspects of dysarthric speech but did not treat it,
2. focused on a single speech subsystem or component, for example, those that focused only on production of sustained phonation in speakers with dysarthria,
3. applied treatment approaches to individuals without impairment, for example, examination of rate and loudness changes in speakers without neurologic impairment,
4. studied techniques for management of global aspects of speech associated with disorders other than dysarthria, for example, treatment of rate and loudness in apraxia of speech, or
5. reported the affects of digital manipulation of recorded sample of dysarthric speech.

Intervention studies that focus on respiratory-phonatory or velopharyngeal aspects of speech production are reviewed in other modules (Spencer et al., 2003; Yorkston et al., 2001b).

Rating the Strength of Evidence

The strength of evidence for behavioral intervention studies can be rated by asking a series of questions.

What Type of Research Is Represented by the Study?

We answered this question by identifying the phase of research adapted from the descriptions of Robey and Schultz (1998) . During *phase I*, hypotheses about treatment efficacy are developed for later testing. Often this involves experimental manipulations to test the potential benefits or activity of a particular treatment; for example, asking a speaker with Parkinson's disease (PD) to speak slowly or loudly and then measuring the acoustic, physiologic, or perceptual consequences of that manipulation. In this review, studies in which global aspects of speech were manipulated experimentally were designated as phase I studies. During *phase II*, the goals are to formulate and standardize protocols, validate measurement instruments, optimize dosage of treatment, and so on. For this review, articles were placed in this category if a treatment protocol was carried out for a speaker with dysarthria. Articles in this category were case reports or small group studies with no control groups or treatment comparisons. During *phase III,* treatment efficacy of a specified protocol is formally tested either with single participant design research or group studies with controls such as control groups or treatment comparisons.

How Well Are the Participants Described?

We answered this question by noting the presence or absence of 18 participant descriptors similar to those described elsewhere (Strand & Yorkston, 1994). The level of description was categorized as *brief* if 1–5 characteristics were included in the article, *detailed* if 6–10 were included, and *comprehensive* if more than 10 were included. In addition, information about the following participant-related characteristics is provided: number of participants, type of dysarthria, severity of dysarthria, medical diagnosis, age, and gender.

Are the Consequences of the Intervention Well Described?

We answered this question by noting evidence for control, that is, evidence that changes were the result of intervention and not some other variables. The following are examples of factors that suggest control: presence of stable baseline, outcome measures obtained with and without a device, improved speech performance with intervention in the face of a progressive disorder, and presence of a comparison or control group. The types of outcomes measures were also noted in the following categories: acoustic, physiological, perceptual, or psychosocial. See Technical Report 6 for specific outcomes measures in each of these categories. Finally, a summary of the study conclusions is provided.

RESULTS AND DISCUSSION

A total of 51 intervention studies were identified, obtained, and rated by at least two members of the Writing Committee. Articles describing and reporting the effectiveness of treatment of the global aspects of speech in dysarthria have appeared for over 30 years: nine were published before 1985, 10 between 1985 and 1994; and 32 between the years 1995 and 2004. Intervention studies were categorized into four groups, those focusing on loudness (N = 21), speaking rate (N = 19), prosody (N = 10), and general instructions (N = 6). Note that a number of articles were placed in more than one category. For example, if a study had a condition involving rate and a condition involving loudness, the study was placed in both categories. The following sections describe each of the treatment categories: loudness, rate, prosody, and general instructions. Characteristics of these studies are summarized in a series of Tables of Evidence (Tables 1, 3–5). Studies are listed in chronological order of publication.

Loudness

Table of Evidence: Loudness (Table 1) summarizes 21 articles reporting outcomes of treatment focusing on increasing speech loudness. Note that most studies (N = 11: 52%) are phase II studies (preliminary investigation of intervention protocols), and some (N = 7: 33%) are phase III (a specific protocol is formally tested).

Treatment

While increasing loudness may be a common treatment goal for individuals with various dysarthria types, including flaccid, hypokinetic, and mixed, most evidence-based treatments for increasing loudness stem from research in the area of PD (Adams, 1997). Reduced loudness is one of the primary perceptual features of the hypokinetic dysarthria in PD. This type of dysarthria is common because of the high prevalence of PD in the aging population and the high prevalence of dysarthria in PD. Increasing respiratory/phonatory effort, thus increasing loudness, has been the focus of a systematic program line of treatment research conducted by Ramig and colleagues (Ramig, Fox, & Sapir, 2004). The majority of studies in this category focused on Lee Silverman Voice Treatment (LSVT), an intensive, high-effort speech treatment designed to rescale the magnitude of motor output of speakers with PD (Ramig, Pawlas, & Countryman, 1995). Goals are to increase phonatory effort, vocal fold adduction, and respiratory support. LSVT was designed to improve the perceptual characteristics of voice by targeting loudness. This treatment approach is well described and thus can be replicated from clinic to clinic.

Speakers' Characteristics

A total of 308 participants participated in this group of studies. This total may overestimate the number of individuals because some are represented in multiple studies. For example, studies reporting the impact of LSVT on aerodynamics (Ramig, Countryman, Thompson, & Horii, 1996) are reported separately from those reporting acoustic findings (Ramig et al., 1995). Generally, the participations were well described, with 45% of studies providing comprehensive descriptions of participants and 45% detailed descriptions. The majority of participants (76%) described in this series of studies had a diagnosis of PD and exhibited symptoms consistent with hypokinetic dysarthria, including phonatory hypoadduction and decreased vocal loudness.

TABLE 1. Table of Evidence: Loudness.

			Subjects								Measures				
Reference	**Phase of Research**	**Intervention**	**Number of Subjects**	***Level of* Description**	**Medical Dx**	**Type of Dysarthria**	**Severity-Intellig. Rating**	**Age Range**	**Gender**	**Evidence for Control**	**Acoustic**	**Physiologic**	**Perceptual**	**Psycho-Social**	**Study Conclusions**
Countryman & Ramig (1993)	Phase II	LSVT	1	Comprehensive	PD (with bilateral thalamotomy)	Mixed hypokinetic-spastic	Mild dysarthria; moderate voice disorder	65	F	Change in patient with degenerative disease. Two baseline measures.	+		+	+	*After 16 sessions of LSVT in one* month, acoustic outcome measures were significantly improved immediately following treatment. The patient's and SLP's perceptual ratings also noted improvement pre- to posttreatment. However, 6 and 12 months posttreatment, acoustic measures indicated deterioration to or below baseline levels.
Countryman et al. (1994)	Phase II	LSVT	3	Comprehensive	PSP, multiple system atrophy, Shy-Drager syndrome	Not specified	Moderate to severe	59–73	1M: 2F	Change in behavior demonstrated in patients with degenerative disease.	+		+	+	Objective & perceptual data supported improvement of speech & voice deficits in all three patients following one month of LSVT. Increased intensity contributed to improved intelligibility & functional communication as reported by SLPs, patients, & family. By 6 months posttreatment, the patients' objective & perceptual data had declined from immediately posttreatment levels. However, the patients & families reported overall functional communcation skills remained above pretreatment performance.
Ramig et al. (1994)	Phase II	LSVT	40	Detailed	PD	Hypokinetic	Not specified	53–86	30M: 10 F	Change in behavior demonstrated in patients with degenerative disease.	+		+		Findings support the effectiveness of LSVT for patients with PD. Statistically significant differences were measured pre- to posttreatment on maximum vowel *duration, F0 range, mean* F0, and F0 variability (reading). Improvement in perceptual measures documented as well. Improvements were maintained at 6 & 12 months whether or not subjects received additional treatment.

			Subjects								Measures				
Reference	Phase of Research	Intervention	Number of Subjects	Level of Description	Medical Dx	Type of Dysarthria	Severity-Intellig. Rating	Age Range	Gender	Evidence for Control	Acoustic	Physiologic	Perceptual	Psycho-Social	Study Conclusions
Dromey et al. (1995)	Phase II	LSVT	1	Comprehensive	PD	Not specified probably hyperkinetic	Mild	49	M	Baseline measures. Parallel changes observed in correlated variables.	+	+			LSVT resulted in increased vocal intensity; this also led to changes in articulation that were not targeted in treatment. Pt. Increased his vocal intensity using phonatory mechanisms associated with the nondisordered larynx.
Ramig et al. (1995)	Phase III	LSVT	45	Comprehensive	PD	Not specified (probably hypokinetic)	Mild-severe	32–81	12F; 33M	Randomized groups. Significant effects with patients with degenerative disorder.	+		+	+	LSVT, focusing on increased vocal fold adduction, is more effective than respiration treatment alone for improving vocal intensity and decreasing the impact of PD on communication.
Smith et al. (1995)	Phase III	LSVT vs respiratory only	22	Detailed	PD	Not specified (probably hypokinetic)	Dysarthria severity not specified	49–76	17M: 5F	Randomized tx groups. Improvement in degenerative disease.		+			Patients with PD who underwent the combined vocal & respiratory treatment demonstrated improved laryngeal adduction which was correlated with increased vocal intensity. No differences were observed in the respiratory only group.
Ramig & Dromey (1996)	Phase III	LSVT vs respiratory only	17	Detailed	PD	Not specified (probably hypokinetic)	Mild-severe	51–83	NA	Subset of patients was (previously) randomized into treatment groups.		+			Subjects who received the LSVT were able to achieve increases in SPL through improved vocal fold adduction & increase in subglottal pressure. SPL did not consistently increase pre- to posttreatment for subjects who received only respiratory training.

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TABLE 1. *(continued)*

			Subjects								Measures				
Reference	**Phase of Research**	**Intervention**	**Number of Subjects**	**Level of Description**	**Medical Dx**	**Type of Dysarthria**	**Severity-Intellig. Rating**	**Age Range**	**Gender**	**Evidence for Control**	**Acoustic**	**Physiologic**	**Perceptual**	**Psycho-Social**	**Study Conclusions**
Ramig et al. (1996)	Phase III	LSVT vs respiratory only	35	Detailed	PD	Not specified (*probably* hypokinetic)	Mild-*severe*	Mn: 63	NA	Random assignment to treatment groups; use of a comparison group.	+			+	Findings support the short- and long-term effectiveness of intensive voice therapy (LSVT) for improving vocal intensity in patients with PD. Placebo group made some improvements immediately after treatment, but they were unable to maintain those improvements up to 12 mo after tx. Only LSVT subjects rated a significant reduction in the impact of their sickness on their communication skills after treatment.
Countryman et al. (1997)	Phase II	LSVT	1	Comprehensive	PD	Not specified (probably hypokinetic)	Mild-moderate	60	1M	Multiple pre-post measures, degenerative condition.	+	+	+		In this individual, LSVT increased vocal loudness, decreased supraglottic hyperadduction, & improved intonation & overall voice quality. Supraglottic hyperadduction was due to a secondary compensatory behavior resulting from mild true vocal fold hypoadduction that responded positively to adduction therapy (LSVT).
Theodoros et al. (1999)	Phase II	LSVT	1	Comprehensive	PD	Hypokinetic	Severe	58	F	Baseline assessments; degenerative condition.	+	+	+		LSVT was effective for this patient with severe hypokinetic dysarthria following stereotactic surgery. Specifically, results demonstrated marked improvement in the subject's speech intelligibility immediately post-LSVT
Ward et al. (2000)	Phase II	LSVT	30	Detailed	PD with or without pallidotomy and/or thalamotomy	Not specified (probably hypokinetic)	Mild-severe	Mn: 65–68	20M: 10F	Clinical comparison group; degenerative condition.		+		+	Only the nonsurgical PD patients had an increase tongue pressure posttreatment.

			Subjects								Measures				
Reference	Phase of Research	Intervention	Number of Subjects	Level of Description	Medical Dx	Type of Dysarthria	Severity-Intellig. Rating	Age Range	Gender	Evidence for Control	Acoustic	Physiologic	Perceptual	Psycho-Social	Study Conclusions
Kleinow et al. (2001)	Phase I	Experimental manipulation of rate & loudness	8	Detailed	PD	Hypokinetic	Mild-moderate	57–78	5F;3M	2 control groups (young and old)	+				Slow rate was associated with greatest variability; loud condition closest to habitual.
Ramig, Sapir, Fox et al. (2001)	Phase III	LSVT	14	Detailed	PD	Not specified (probably hypokinetic)	Mild to severe	Mn: 68	7M: 7F	Random assignment; use of clinical (PD) & nonclinical comparison groups; degenerative condition.	+				Subjects with PD who underwent LSVT treatment showed a significant increase in voice SPL from baseline to posttreatment & from baseline to the 6-month follow-up. Subjects with PD who did not receive treatment, as well as the non-brain-injured control subjects, did not demonstrate a significant increase in SPL. This suggests that the effects of LSVT are treatment-specific & not related to extraneous factors.
Sapir et al. (2001)	Phase II	LSVT	2	Detailed	MS	Not specified	Not specified	47–48	2F	Progressive condition. 3 baseline measures	+		+	+	Subjects demonstrated statistically significant improvement in SPL & duration of sustained phonation from pretreatment to posttreatment & to the 6-month follow-up. Significant improvement was also observed in the perceptual rating of voice loudness after treatment. Both subjects indicated improved functional communication & quality of life following LSVT treatment.
Solomon et al. (2001)	Phase II	LSVT vs respiratory tx	1	Comprehensive	TBI	Mixed hypokinetic-spastic	Moderate - severe	23	M	Comparison treatments. Time post onset	+	+	+	+	After LSVT alone, improvements were generally minor & inconsistent, although sound pressure level & loudness increased notably. However, after an additional 6 weeks of intensive Combination Treatment (LSVT plus respiration & PT), gains were documented for resting & speech breathing, vocal intensity, & sentence intelligibility. Several measures returned to baseline at the 3 months after treatment ceased, but some improvements in resting & speech breathing remained.

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TABLE 1. *(continued)*

			Subjects								Measures				
Reference	**Phase of Research**	**Intervention**	**Number of Subjects**	**Level of Description**	**Medical Dx**	**Type of Dysarthria**	**Severity-Intellig. Rating**	**Age Range**	**Gender**	**Evidence for Control**	***Acoustic***	**Physiologic**	**Perceptual**	**Psycho-Social**	**Study Conclusions**
Ramig, Sapir, Countryman et al. (2001)	Phase III	LSVT vs respiratory only	21	Detailed	PD	Not specified (probably hypokinetic)	Mild to moderate	Mn: 61	17M: 4F	Random assignment; degenerative condition.	+				LSVT was significantly more effective than the respiratory-only therapy in improving sound pressure level & pitch variability immediately posttreatment & maintaining those improvements at the 2-year follow-up.
Baumgartner et al. (2001)	Phase III	LSVT vs respiratory effort	13	Detailed	PD	Not specified (probably hypokinetic)	Moderate	Mn: 67	11M: 2F	Randomly assignments after stratification. Listeners blinded			+		*Statistically* significant pre- & posttreatment improvement in hoarseness & breathiness was observed in the LSVT group, but not in the group that received respiratory therapy alone.
Huber et al. (2003	Phase II	LSVT	6	Brief	PD	Not specific, probably hypokinetic	Not specified	63–78	1F; 5M	3 control Ss	+	+			Increased SPL when they were externally cued to be louder and post-LVST. SPL increase & the strategies used for increasing SPL varied both within and across subjects.
Sapir et al. (2003)	Phase II	LSVT	1	Comprehensive	encephalo-pathy	Ataxic	Mild to moderate	48	1F	Pre-post tx	+		+	+	Short & long-term improvement in phonatory & articulatory function, speech intelligibility & overall communication & job-related activity.
Tjaden & Wilding (2004)	Phase I	Habitual, loud, & slow	27	Comprehensive	MS PD	Spastic, ataxic, hypokinetic, mixed	Mild to severe	25–62	16F; 11M	2 disorder & 1 control group; condition comparisons	+		+		Vowel distinctiveness was maximized by slow rate, stop consonant distinctiveness by loud speech.
	PD = Parkinson Disease: PSP = Progressive supranuclear palsy														

A profile of candidacy requirements emerges from a review of the literature. This candidacy profile is based on a constellation of symptoms (reduced loudness, poor respiratory support/effort), good stimulability such that performance improved with appropriate cues, and a high level of motivation to participate actively in an intensive program of practice. Ramig and colleagues (2004) suggest that individuals with mild-moderate PD have the most positive outcomes and thus are the best candidates for LSVT. Preliminary data are reported for speakers with diagnoses other than PD, namely multiple sclerosis (MS) and traumatic brain injury (TBI). Because the dysarthria types associated with MS or TBI are variable, some individuals with these diseases also fit the symptom profile, that is, symptoms reflected vocal weakness or fatigue, and reduced vocal loudness. Success of LSVT has been reported in a limited number of speakers with MS and TBI who fit the candidacy profile. In one case report of a speaker with TBI, outcomes were most beneficial when LSVT was combined with respiratory exercises (Solomon, McKee, & Garcia-Barry, 2001).

Outcome

Generally, statistically significant improvement was noted in participants with PD who completed the 16-session protocol for LSVT. Although the primary outcome measures were acoustic variables, physiologic and perceptual measures were also reported. Evidence for the effectiveness of LSVT was strengthened by studies where LSVT was compared with other treatments such as those employing a respiratory only approach and those reporting long-term (2-year) follow-up data. Ramig and colleagues (2004) suggest that targeting loudness and phonatory effort not only improves vocal characteristics but also "appears to trigger effort and coordination across the speech mechanism" (p. 176). The trigger effect is supported by the evidence that both the primary outcome measure (loudness) and important secondary measures such as articulatory precision improve with treatment.

Summary of Current Status

A substantial number of studies have been published since 1990 that focus on increasing loudness in speakers with dysarthria. Most represent a systematic line of research conducted by Ramig and colleagues with the PD population. As is typical in treatment efficacy research, early studies utilize case reports or small group studies. These were followed by larger group studies with more controls such as comparison of treatments or long-term follow-up. LSVT is well described, is linked with the physiologic and perceptual features of dysarthria associated with PD, and follows a precise treatment protocol that specifies both type and intensity of treatment. Participants are well described and come from a well-defined population. The consequences of intervention are reported in detail using multiple physiologic, perceptual, and acoustic measures. Treatment outcome has been positive, with changes not only in loudness but also on other aspects of speech production such as articulatory precision. The following is a description of the current status and future needs for treatment research targeting improvement of loudness. See Table 2 for a summary of current status and future research needs.

Speaking Rate

Table of Evidence: Rate (Table 3) summarizes 19 articles reporting outcomes of treatment focusing on manipulation speaking rate. Note that most studies (N = 10: 53%) are phase I studies (testing potential benefits of intervention) and some (N = 8: 42%) are phase II (preliminary investigation of intervention protocols).

Treatment

Rate control is a long-standing strategy in dysarthria treatment because some speakers are much easier to understand when they slow their rate of speech (Yorkston, Beukelman, Strand, & Bell, 1999). This systematic review yielded articles that describe a variety of approaches to changing speaking rate. As highlighted in Table 3, rate was manipulated via numerous techniques including (1) external pacing devices (DAF, pacing board, metronome; n = 5); (2) computer training (n = 3), behavioral instructions (n = 10); and (3) biofeedback (n = 1). In the majority of the studies, target rates were slow relative to the speakers' habitual rates. Only 2 of the 19 studies (11%) contained some speakers whose goal was to increase rate. For example, Hodge and Hall (1994) reported the case of an 11-year-old boy with a diagnosis of hypoxic encephalopathy whose rate was extremely slow (< 1 syl/sec). Treatment focused on increasing rate in order to decrease unusual stress patterning.

TABLE 2. Summary of current status and tuture needs

Treatment	Current Status	Future Needs
Loudness	❑ Well-defined, replicable protocol ❑ Relatively large subject pool ❑ Relatively well-defined subject population ❑ Linked to physiologic-perceptual features ❑ Progressed from case to group studies with controls ❑ Measured multiple aspects of speech ❑ Trigger effect (loudness changes prompted other benefits)	❑ Measure of outcomes in natural social situations ❑ Impact of intervention on communicative participation ❑ Usefulness of LSVT fpopulations other than PD ❑ Examination of factors that may optimize learning (e.g., schedule and intensity of intervention)
Rate	❑ Modifying rate may be a powerful technique for improving intelligibility in some speakers with dysarthria ❑ A variety of techniques are available for training ❑ Durational aspects of speech can be precisely measured using acoustic techniques	❑ *Examination of generalization of training* ❑ Techniques to document psycho-social outcomes ❑ Better understanding of candidacy ❑ Treatment studies comparing various techniques ❑ Parameters of treatment scheduling (frequency, intensity, and duration of training) ❑ Better description of how optimal rate is selected & trained
Prosody	❑ May enhance linguistic information thus intelligibility ❑ Computer-assisted acoustic analysis provides immediate, quantitative feedback	❑ Comparison of various approaches ❑ Documentation of social validity ❑ Documentation of generalization of training ❑ *Techniques for perceptual rating of prosody* ❑ Understanding the interaction of timing, loudness and pitch manipulation ❑ Study of the acoustic variables (or combination of variables) that contribute to speech naturalness ❑ Development of candidacy profiles
General Instructions	❑ Takes advantage of residual compensatory capabilities ❑ May be applied to speakers with many types of dysarthria	❑ Studies of candidacy issues ❑ Larger groups of speakers ❑ More attention to actual *rather than* simulated communication breakdowns

Speaker Characteristics

A total of 121 participants participated in treatment studies focusing on rate. Twenty-one percent of the studies provided comprehensive descriptions of participants, 63% detailed, and 16% brief descriptions. Unlike treatment of loudness, where PD was the predominant medical diagnosis, treatment focusing on speaking rate was applied to people with a variety of medical diagnoses and dysarthria types. Medical diagnoses of participants included PD, TBI, CP, anoxia, tumor, ALS, and others. Because of the variety of medical diagnoses represented, it is not surprising that many types of dysarthria were *also represented with hypokinetic*, mixed, ataxic, and spastic types the most common. Although a range of severity from mild to profound is represented, most of the participants exhibited decreased speech intelligibility. Ages ranged from 5 to 78 years, but most participants were *adults*.

TABLE 3. Table of Evidence: Rate.

			Subjects								Measures				
Reference	**Phase of Research**	**Intervention**	**Number of Subjects**	**Level of Description**	**Medical Dx**	**Type of Dysarthria**	**Severity-Intellig. Rating**	**Age Range**	**Gender**	**Evidence for Control**	**Acoustic**	**Physiologic**	**Perceptual**	**Psycho-Social**	**Study Conclusions**
Helm (1979)	Phase II	Pacing board	1	Brief	PD	Not given	Non-communicative, severe	54	M	Speech with and without the board			+		A simple wooden pacing board was effective in controlling palilalia.
Hanson & Metter (1980)	Phase II	Delay Auditory Feedback devise	1	Detailed	Supra-nuclear Palsy	Hypokinetic	7-point equal appearing interval scale	59	M	Multiple baseline design, interrater reliability high	+		+	+	Rate decreased by half, median vocal intensity increased, & intelligibility rated at median of 6.43 (7 being most severe) without DAF & 1 (normal) with DAF
Yorkston & Beukelman (1981)	Phase I	Various rate control techniques, prosody enhancement	4	Detailed	TBI, anoxic enceph-alopathy	Ataxic	Severe (initially compromised intelligibility)	23–55	4M		+		+		Intelligibility improved & Ss were able to signal stress patterning.
Berry & Goshorn (1983)	Phase II	Oscilloscopic feedback of time by intenisty trace	1	Detailed	CVA	Ataxic	severe	60	M		+		+		Supports efficacy of tx using visual feedback to slow rate.
Hanson & Metter (1983)	Phase II	Delay Auditory Feedback devise	2	Comp.	PD	Hypokinetic	1 moderate; 1 severe	56–58	1 M and 1F	Interrater reliability high for judges	+		+		Both subjects increased intelligibility, F0 & vocal intensity with DAF. Only subject 1 decreased rate. Subject 1 later broke the device and decided not to use one further.

(continues)

TABLE 3. *(continued)*

			Subjects								Measures				
Reference	**Phase of Research**	**Intervention**	***Number of Subjects***	**Level of Description**	**Medical Dx**	**Type of Dysarthria**	**Severity-Intellig. Rating**	**Age Range**	**Gender**	**Evidence for Control**	**Acoustic**	**Physiologic**	**Perceptual**	**Psycho-Social**	**Study Conclusions**
Yorkston et al. (1990)	Phase I	4 computer-presented rate control strategies	8	Detailed	PD, CP, Cerebellar degen., TBI, tumor	Hypokinetic or ataxic	Under 90% intelligibility	30–70	2F; 6M	Judges naïve; measures both actual and target rates.			+		*Reducing rate* increased intelligiblity, not as much impact on naturalness for speakers with dysarthria as the normal controls when reducing rate.
Thomas-Stonell et al. (1991)	Phase II	Rate training using computer game	3	Detailed	TBI; myotonic dystrophy	Not specified	Mild, mod and severe	5–18	1F; 2M	Multiple baseline design with counter-balancing and replication	+		+		SpeechViewer & the rate control program were effective tools for modifying speech attributes & improving intelligibility. Four of the six multiple baseline treatment phases analyzed statistically revealed significant training effects.
Le Dorze et al. (1992)	Phase II	F0 modulatation *and rate*	1	Comp.	PD	Hypokinetic	Moderate	74	F	Multiple baseline across behaviors design	+		+		The patient benefited from speech intervention with positive effects such as improved prosody & intelligibility of speech. Independent judges were more capable of understanding the patient's speech after therapy.

			Subjects								Measures				
Reference	**Phase of Research**	**Intervention**	**Number of Subjects**	**Level of Description**	**Medical Dx**	**Type of Dysarthria**	**Severity-Intellig. Rating**	**Age Range**	**Gender**	**Evidence for Control**	**Acoustic**	**Physiologic**	**Perceptual**	**Psycho-Social**	**Study Conclusions**
Hodge & Hall (1994)	Phase II	Elimination of within-utterance inspiration; increase number of syllables in 4 secs.	1	Comp.	Hypoxic encephalo-pathy	Spastic-ataxic	Severe (due to extremely slow rate)	11	M	Used a time-series, changing criterion design.			+		Speech rate increased approximately 16% from baseline. The patient was able to eliminate within-utterance inspirations; however, the authors reported the observation of other aberrant respiratory behaviors.
Turner et al. (1995)	Phase I	Instructions to read at fast, slow & habitual rate	9	Detailed	ALS	Mixed flaccid-spastic	Single word intelligibility 38-97	34–68	4F; 5M	Matched controls	+		+		Dysarthric speakers exhibited smaller vowel space areas & less systematic changes in vowel space as a function of speaking rate than control. Vowel space account for 45% of variance in speech intelligibility
Dagenais et al. (1998)	Phase III	DAF, DAF & traditional, DAF & prolongation	3	Detailed	PD	Hypokinetic	Moderate	63–78	3M and 1F	Multiple baseline single case design	+		+		DAF not an effective method for decreasing speech rate; prolonged speech did "improve" rate while maintaining intelligibility; results varied from cases to case.

(continues)

TABLE 3. *(continued)*

			Subjects								Measures				
Reference	**Phase of Research**	**Intervention**	**Number of Subjects**	**Level of Description**	**Medical Dx**	**Type of Dysarthria**	**Severity-Intellig. Rating**	**Age Range**	**Gender**	**Evidence for Control**	**Acoustic**	**Physiologic**	**Perceptual**	**Psycho-Social**	**Study Conclusions**
Pilon et al. (1998)	Phase I	Rate reduction: metronome pacing, singing pacing, visuospatial cures and no pacing.	3	Detailed	TBI	Spastic-ataxic	Mild-mod and mod-severe	23–44	3M	Comparison with no pacing	+		+		Significant change in 2/3 speakers (with more severe dysarthria) for all pacing strategies; improved intelligibility was closely related to slowed rate; may have differential benefits contingent on severity of dysarthria.
Weismer et al. (2000)	Phase I	Sentences produced at habitual and fast rates	10	Brief	ALS	Spastic-flaccid	Mild-moderate (78–100% on Kent words)	55	5F; 5M	Conditions compared	+		+		Both normal & ALS speakers showed compressed vowel space with increased rates; no change in intelligibility or severity with increased rate.
Kleinow et al. (2001)	Phase I	Experimental manipulation of rate & loudness	8	Detailed	PD	Hypokinetic	Mild-moderate	57–78	5F; 3M	2 control groups (young and old)		+			Slow rate was associated with greatest variability; loud condition closest to habitual.
Thomas-Stonell et al. (2001)	Phase II	Rate training using computer game	12	Detailed	Various: TBI, DD, CP, Tumor	Spastic or Flaccid	Mild to severe	4–20	5F; 7M	Present	+				Program effective for modifying speech rate in children & adolescents with dysarthria.

			Subjects								Measures				
Reference	**Phase of Research**	**Intervention**	**Number of Subjects**	**Level of Description**	**Medical Dx**	**Type of Dysarthria**	**Severity-Intellig. Rating**	**Age Range**	**Gender**	**Evidence for Control**	**Acoustic**	**Physiologic**	**Perceptual**	**Psycho-Social**	**Study Conclusions**
Hustad & Sassano (2002)	Phase I	Examined effect of speaker-implemented interword pauses vs habitual and digital manipulation	2	Detailed	Spastic diplegia	Spastic	Severe-profound	50 & 42	M & F	Conditions compared	+		+		Deliberate pause insertion (DP condition) yielded greatest increases in speech intelligibility. Authors conclude that DP may provide listeners with clearer word boundaries, production-based changes assoc. with reduce artic. rate & increased processing time.
McHenry (2003)	Phase I	Habitual, fast, stretched, with breaks	12	Detailed	TBI	Flaccid, spastic, hyopkinetic, or mixed	Mild to moderate or moderate to severe	20–40	1F; 11M	Grouped by severity of dysarthria with control Ss		+			Slowing the speaking rate in individuals with dysarthria reduces spatiotemporal variaiblity; however, the effect of reduced spatiotemporal variability on intelligibility requires further study. STI values of moderate-severe speakers were different from controls.
Tjaden & Wilding (2004)	Phase I	Habitual, loud, & slow	27	Comp.	MS PD	Spastic, ataxic, hypokinetic, mixed	Mild to severe	25–62	16F; 11M	2 disorder & 1 control group; condition comparisons	+		+		Vowel distinctiveness was maximized by slow rate, stop consonant distinctiveness by loud speech.

ALS = Amyotrophic lateral sclerosis: CP = Cerebral Palsy: CVA = Cerebrovascular Accident: DD = Developmental Delay: MS = Multiple sclerosis: PD = Parkinson's disease: TBI = Traumatic brain injury: Comp = Comprehensive.

Outcome

Outcomes were measured using a variety of techniques. Although multiple dimensions were frequently measured, perceptual ratings of variables such as intelligibility were the most common (79% of the studies). Acoustic measures were reported in 74% of the studies. Physiologic (11%) and psycho-social measures (5%) were reported much less frequently.

Generally, this group of studies supports the relationship between speaking rate and intelligibility in dysarthria, with changes in rate affecting intelligibility. Initially, the evidence for this relationship took the form of illustrative cases in which decreasing rate was associated with increasing intelligibility (Yorkston & Beukelman, 1981). Later, the relationship was examined in more detail and included acoustic (Turner, Tjaden, & Weismer, 1995) and physiologic data (McHenry, 2003).

A number of studies suggested that the relationship between rate and intelligibility is not a simple one. The following are examples of research findings related to rate and intelligibility. With the manipulation of rate, vowel space accounted for only 45% of the variance in speech intelligibility (Turner et al., 1995). As rate was decreased, sentence intelligibility but not phoneme intelligibility improved (Yorkston, Hammen, Beukelman, Traynor, 1990). Decreasing rate did not disrupt naturalness in dysarthric speech as much as it does in typical speech (Yorkston et al., 1990). Studies suggest that a variety of techniques can be used to modify rate. Outcomes depend, at least in part, on the severity of the dysarthria. Further, some authors suggested a "threshold of benefit" (Pilon, McIntosh, & Thaut, 1998) that may help to dictate candidacy for treatment focusing on speech rate.

Summary of Current Status

Some of the earliest studies of treatment efficacy in dysarthria focused on modification of speaking rate. For the most part, rate modifications were intended to slow speaking rate as a means of improving speech intelligibility. Approximately half of the studies identified in this review were phase I studies where the impact of rate manipulation was studied in an experimental context. Findings of this phase of research suggest the potential benefit of rate control in dysarthria, but benefits seem dependent on a number of factors that require further investigation including characteristics of both the dysarthria and intervention strategies. A variety of treatment techniques were reported but many were restricted to experimental conditions, for example, computer-assisted pacing strategies. Investigation of the generalization of these techniques to natural communication settings is an important next step in this line of research. Participants reported in this study represented many types of dysarthria and many medical diagnoses. Explicit descriptions of candidacy for rate reduction are generally lacking. See Table 2 for a summary of current status and future research needs.

Prosody

Table of Evidence: Prosody (Table 4) summarizes 10 articles reporting outcomes of treatment focusing on enhancing prosody, that is, rate, rhythm, and intonation. Most of the studies (N = 7: 70%) are phase II studies (preliminary investigation of intervention protocols) and some (N = 3: 30%) are phase I studies (testing potential benefits of intervention).

Treatment

Prosody or suprasegmental aspects of speech includes a number of features that extend across a series of sound segments, including stress patterning, intonation, and rate-rhythm. Prosody is achieved through a complex interaction of rate, loudness, and pitch adjustments. Prosodic abnormalities are common in dysarthria and are frequently associated with ataxic dysarthria because of the perceptual feature of "excess and equal" stress patterning, with hypokinetic dysarthria because of the perceptual features of monoloudness and monopitch, and with hyperkinetic dysarthria secondary to variable stress patterns. A variety of treatment approaches were found in the current review. Techniques comprised two primary areas: biofeedback (n = 5) and behavioral instruction (n = 6). To illustrate, some involved providing various types of acoustic feedback to the speaker. Other techniques relied on the linguistic function of prosody and asked speakers to produce utterances with various emphatic stress patterns.

Speaker Characteristics

A total of 32 participants took part in treatment studies focusing on prosody. A third (33%) of the studies provided comprehensive participants description, 55% detailed and 11% brief participant descriptions. Most participants (50%) had a diagnosis of TBI, but other diagnoses include MS, CVA, PD, anoxia, encephalopathy, and CP. The most common type of dysarthria was ataxic, reported in 50%

TABLE 4. Table of Evidence: Prosody.

			Subjects								Measures				
Reference	**Phase of Research**	**Intervention**	**Number of Subjects**	**Level of Description**	**Medical Dx**	**Type of Dysarthria**	**Severity-Intellig. Rating**	**Age Range**	**Gender**	**Evidence for Control**	**Acoustic**	**Physiologic**	**Perceptual**	**Psycho-Social**	**Study Conclusions**
Yorkston & Beukelman (1981)	Phase I	Various rate control techniques, prosody enhancement	4	Detailed	TBI, anoxic enceph-alopathy	Ataxic	Severe (initially compromised intelligibility)	23–55	4M		+		+		Intelligibility improved & speakers were able to signal stress patterning.
Caligiuri & Murry (1983)	Phase II	Oscilloscopic feedback duration intensity intra oral air pressure.	3	Detailed	CVA, MS	Pseudobulbar, ataxic	Not specified	59–75	3M	Blinded comparison of pre-post treatment			+		Nine weeks of visual feedback resulting in improvement in speaking rate, prosodic control, & reduction in overall severity.
Simmons (1983)	Phase II	Loudness-pitch variation, word/sentence stress patterns, syllable duration, & decreasing exaggeration.	1	Detailed	TBI	Ataxic	Moderate "sounded like a computer."	26	M	Comparison of patient to two normal speakers.	+				The patient showed improved scores on tasks designed to measure prosody, & objective changes in acoustic properties on the spectrogram. However, speech did not approach normal. Spectrographic analysis proved beneficial for monitoring, but feedback should be immediate.
Bellaire et al. (1986)	Phase II	Increase words/ breath and pauses *w/o inhalation*	1	Detailed	TBI	Not specified	AIDS= 5mpo-56%, 9mpo-97%	20	M	Pre- and post-tx measures; control data	+		+		Patient was able to increase the length of the breath groups & pause without inhalation. Independent judges agreed speech was more natural after treatment.

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TABLE 4. *(continued)*

			Subjects								Measures				
Reference	**Phase of Research**	**Intervention**	**Number of Subjects**	**Level of Description**	**Medical Dx**	**Type of Dysarthria**	**Severity-Intellig. Rating**	**Age Range**	**Gender**	**Evidence for Control**	**Acoustic**	**Physiologic**	**Perceptual**	**Psycho-Social**	**Study Conclusions**
Le Dorze et al. (1992)	Phase II	F0 modulatation and rate	1	Comprehensive	PD	Hypokinetic	Moderate	74	F	Multiple baseline across behaviors design	+		+		The patient benefited from speech intervention with positive effects, e.g., improved prosody & intelligibility. Independent judges were more capable of understanding speech after therapy.
Bougle et al. (1995)	Phase II	Prosody training with either clinician or computer feedback re: F0	2	Comprehensive	TBI	Ataxic	Mild to moderate	23–28	1F; 1M	Limited. Alternating treatments design; 4 baseline measures.	+		+		No obvious difference in treatment effectiveness; both treatments were equally effective in improving F0 modulation. Immediate maintenance of treatment demonstrated for one subject.
Cohen (1995)	Phase II	Vocal instruction and Visi-Pitch feedback	2	Detailed	CVA	Both anomic aphasia & dysarthria in C1; aphasia, apraxia & dysarthria in C2	Inteligibility was 63 and 31%; severe dysarthria	Not specified	Not specified	Limited. Used a pretest-postest design.	+		+		S1 experienced a 38% improvement in pause time & in vocal intensity; no changes in speaking fundamental frequency range or intelligibility. S2 experienced a reduction in pause time, an increase in vocal intensity, & an 11% increase in intelligibility

			Subjects								Measures				
Reference	Phase of Research	Intervention	Number of Subjects	Level of Description	Medical Dx	Type of Dysarthria	Severity-Intellig. Rating	Age Range	Gender	Evidence for Control	Acoustic	Physiologic	Perceptual	Psycho-Social	Study Conclusions
Hartelius et al. (1997)	Phase II	Multiple types of tx: Vocal efficiency, contrastive stress, and verbal repair stragegies	7	Comprehensive	MS	Ataxic & mixed spastic ataxic	Mild - severe	28–49	6F; 1M	Pre-post tx; radnomized judging, degenerative condition.	+		+		5 of 7 individuals showed increased articulatory precision, vocal accuracy, & naturalness post-therapy. Individuals with limited treatment outcome learned to apply techniques to increase their ability to signal stress & make more efficient verbal repairs post-therapy.
McHenry (1998)	Phase I	Sentence produced in response to questions	10	Brief	TBI	Not specified	Mild	19–45	6F; 4M	Control group	+	+	+		Individuals with TBI were significantly less accurate conveying intended stress compared with normal controls. Individuals with TBI produced significantly less difference in duration between stresed & unstressed words.

CVA = Cerebrovascular accident, MS = Multiple sclerosis, PD = Parkinson's disease, TBI = Traumatic brain injury, Comp = Comprehensive.

of the articles. Type of dysarthria was not specified in 30% of studies.

Participants ranged in age from 19 to 75 years. Although a range of severity from mild to severe is represented, reduced speech intelligibility was not always present. Many of the studies (50%) included participants who had mild dysarthria. Abnormalities in naturalness were described. For example, one speaker with dysarthria associated with TBI was described as sounding "like a computer" (Simmons, 1983). Because prosody can be used to signal subtle linguistic information, McHenry (1998) suggested treatment in this area places certain cognitive demands on the speaker. Speakers who are not able to cope with those demands may not be appropriate treatment candidates.

Outcome

The most frequent outcome measures were acoustic parameters (80% of studies) and perceptual ratings (80%). Acoustic measures included fundamental frequency contours, relative intensity, and durational aspects of speech production. Perceptual outcomes included ratings of stress patterning, pause structure, articulatory precision, intelligibility, and naturalness. Generally, studies reported improvement on perceptual measures of prosody and related acoustic parameters; however, speech did not approach normal. Both generalization of treatment effects and their social validity await future investigation. A variety of treatment approaches were studied, some focusing on providing specific, acoustic feedback such as fundamental frequency contours, and others only general feedback regarding stress patterning. Sufficient data are not available to compare the merits of specific versus general approaches to prosody training.

Summary of Current Status

Although prosodic disorders are common in dysarthria, characteristics of these disorders vary greatly depending on the type and severity of dysarthria. This heterogeneity is reflected in the treatment efficacy studies reviewed in this report. Most are case reports using a range of different treatment techniques. Because of the relatively small number of studies and the heterogeneity of treatment techniques and participant characteristics, few conclusions about treatment effectively can be draw at this time. See Table 2 for a summary of current status and future research needs.

General Instructions

Table of Evidence: General Instructions (Table 5) summarizes six articles reporting outcomes of treatment focusing on providing participants with general instructions or feedback regarding the overall clarity or intelligibility of speech. Most (67%) are phase I studies (experimental investigation of factors related to intervention).

Treatment

A variety of techniques were used including instruction to produce "clear speech" and feedback about the "clarity" of utterances. Several studies also investigated speakers' ability to repair an utterance following some indication of misunderstanding. In most cases, the requests for repair were delivered on a predetermined schedule rather than in response to an actual communication breakdown.

Speaker Characteristics

A total of 31 participants are reported in treatment studies focusing on general instructions. A third (33%) of the studies provided comprehensive participants description, 55% detailed descriptions, and 11% brief participant descriptions. Both medical diagnoses and type of dysarthria vary. CVA and TBI are the most common diagnosis, and each is included in 33% of the studies. The most common type of dysarthria reported was mixed, but spastic, athetoid, ataxic, and hypokinetic are also reported in single studies.

Outcome

Perceptual ratings of clarity, intelligibility, and articulatory precision were the most common outcome measures (83% of studies). Acoustic measures were reported in 67% of studies. Specific feedback about the adequacy of production (feedback about clarity of a specific utterance, indication of a misunderstanding) resulted in acoustic changes and improved intelligibility. There is no strong evidence that general instruction to speak clearly results in an important benefit.

Summary of Current Status

Because of the small number of studies, the variety of treatment techniques, and participant characteristics, no conclusions about treatment effectively can be drawn at this time. See Table 2 for a summary of current status and future research needs.

TABLE 5. Table of Evidence: General Instructions.

			Subjects								Measures				
Reference	**Phase of Research**	**Intervention**	**Number of Subjects**	**Level of Description**	**Medical Dx**	**Type of Dysarthria**	**Severity-Intellig. Rating**	**Age Range**	**Gender**	**Evidence for Control**	**Acoustic**	**Physiologic**	**Perceptual**	**Psycho-Social**	**Study Conclusions**
Ince & Rosenberg (1973)	Phase II	Feedback about the clarity	2	Detailed	CVA	Not given	Fair to poor	49–52	2M	TPO			+		Articulation was modified through a combination of procedures, including verbal reinforcement & punishment, providing auditory feedback of verbal behavior, modeling & practice.
Ansel et al. (1983)	Phase II	Partner indications of communication failure	10	Detailed	CP	Athetoid, spastic or mixed	17–93% sentence intelligibility	20–47	3F; 7M	Pre- versus post-feedback response	+		+		The most common adjustment were repetition either partial of total, speakers did not adjust intensity in any systematic way.
Till & Toye (1988)	Phase I	Random feedback about intelligibility (general & specific)	7	Detailed	TBI (n=4) CVA (n=2) PD (n=1)	Not specified	Rated mild or moderate	35–66	1F; 6 M	Comparison group. Outcomes with and without feedback.	+				There was a significant change in VOT after the specific feedback and no significant change in VOT (or any of the parameters studied) after the more general feedback. Use of specific feedback can result in articulatory changes.

(continues)

TABLE 5. *(continued)*

			Subjects								Measures				
Reference	**Phase of Research**	**Intervention**	**Number of Subjects**	**Level of Description**	**Medical Dx**	**Type of Dysarthria**	**Severity-Intellig. Rating**	**Age Range**	**Gender**	**Evidence for Control**	**Acoustic**	**Physiologic**	**Perceptual**	**Psycho-Social**	**Study Conclusions**
Kennedy et al. (1994)	Phase I	Orginal, repaired and modeled productions	4	Brief	ALS; basal ganglia degen.	3 Mixed and 1 Hypokinetic	Severe	39–68	3M and 1F	Comparison to original productions	+		+		Dysarthric speakers with reduced intelligibility produce changes in some acoustic variables in repaired & modeled productions.
Hartelius et al. (1997)	Phase II	Multiple types of tx: Vocal efficiency, contrastive stress, and verbal repair strategies	7	Comprehensive	MS	Ataxic & mixed spastic ataxic	Mild-severe	28–49	6F; 1M	Pre-post tx; radnomized judging, degenerative condition.	+		+		5 of 7 individuals showed increased articulatory precision, vocal accuracy, & naturalness post-therapy. Individuals with limited treatment outcome did learn to apply techniques to increase their ability to signal stress and make more efficient
Beukelman et al. (2002)	Phase I	Instructions to produce "clear speech" (other conditions included topic & alphabet cueing	8	Brief	TBI	Not specified	Moderate to severe	19–44	NA	Comparison of conditions; blinded judges			+		The mean intelligibility score for habitual speech was not statistically different than clear speech.

ALS = Amyotrophic lateral sclerosis, CP = Cerebral palsy, CVA = Cerebrovascular Accident, MS = Multiple sclerosis, PD = Parkinson's disease, TBI = Traumatic brain injury.

CONCLUSIONS AND RECOMMENDATIONS

Reviewing the current status of treatment research and addressing some of the research needs identified as part of this review is one step towards strengthening overall research evidence for the effectiveness of behavioral treatment of dysarthria.

Current Status of Treatment Research

With the possible exception of treatment focusing on loudness, efforts to document the efficacy of treatment focusing on the global aspects of speech, including loudness, rate, and prosody are in the preliminary phase of investigation. This review suggests that the strongest evidence regarding treatment effectiveness is in the area of modification of loudness in individuals with PD who have hypokinetic dysarthria. In this area, treatment efficacy research has progressed from case reports to group studies comparing various treatment approaches or providing information on long-term follow-up. Researchers have also investigated some factors regarding modification of speaking rate that may have an active treatment effect. A number of articles focus on the impact of reduced speaking rate on speech intelligibility. Other clinical investigators have reported cases illustrating the potential benefits of treatment techniques involving prosody and general instructions.

Future Research Needs

Although many interventions were shown to be effective for particular speakers with dysarthria, a number of issues warrant further research. The following discussion describes future research needs that apply to all of the intervention strategies described in this review. Some of these suggestions have been made by the authors of the treatment studies. Others were made by the authors of the current report and those who reviewed a Technical Report 6 (Yorkston, Hakel, Beukelman, & Fager, 2006) upon which this article is based.

Improving the Rigor of Evidence and Its Reporting

More strong treatment research needs to be conducted and reported. For example, more single case design studies are warranted given the heterogeneity of the dysarthric population. In addition to case studies and studies involving single case design, group studies with comparison groups are needed. Designs including long-term follow-up are necessary to determine maintenance of outcomes. Developing an evidence base for making clinical decisions requires that treatment studies be evaluated for the strength of support that they provide for the effectiveness of treatment. Evaluation of individual studies and synthesis of information across studies requires careful, consistent, and detailed reporting. Guidelines for reporting randomized (Moher, Schulz, Altman, & the CONSORT Group, 2001) and nonrandomized behavioral studies (Des Jarlais, Lyles, Crepaz, & the TREND Group, 2004) are available. The TREND Checklist for nonrandomized studies (Des Jarlais et al., 2004) contains a listing of features describing participants, interventions, outcomes, samples size, assignment methods, and so on. Inclusion of these features in reports of behavioral intervention would allow better synthesis of research findings across studies.

Outcomes

Convincing outcome measures are needed to document treatment effectiveness. Although clinical trails typically specify a single primary outcome, the use of a comprehensive set of secondary outcome measures (including measures of the psychosocial aspects of communication) is warranted. Better description of the psychometric adequacy of outcome measures is an important research goal. A number of specific measurement techniques merit further investigation, including techniques for perceptual rating of the adequacy of prosody, measurement of speech intelligibility in adverse conditions such as noise, measurement of listener effort, and measurement of the adequacy of communication in natural settings.

Candidacy Criteria for Specific Types of Treatment

Because a single type of intervention is not likely to be effective for all speakers with dysarthria, research is needed to identify key characteristics of speakers who are likely to benefit from the various types of treatment. These characteristics may include medical diagnosis, type or severity of dysarthria, and pattern of impairment. Further examination of the effects of comorbidities such as cognitive impairment on candidacy is also needed. Studies are required that focus on assessment procedures or protocols to assist clinicians in the selection of specific treatment approaches. Studies are also needed to examine the interaction of various treatment approaches.

The current review of interventions focusing on the global aspects of speech suggests that there are a number of under-represented populations. One of the most important of these groups is children with dysarthria. Techniques that are effective in improving communication function of adults with dysarthria may or may not be appropriate for children. Although studies of children were not systematically excluded from this review, only a handful of studies report the effects of speech treatment in children.

Optimizing Learning and Timing of Intervention

Adequate treatment of a motor speech disorder such as dysarthria requires the incorporation of the principles of motor learning into intervention. Well-designed interventions are critical to assure generalization of training. Studies are needed to establish best practices in terms of optimal frequency, intensity, and duration of intervention, as well as frequency and type of feedback. Examination of the role of maintenance treatment in the various types of dysarthria is also called for.

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