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Nancy Helm-Estabrooks, Sc.D., BC-NCD

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Speech Supplementation Techniques for Dysarthria: A Systematic Review

Elizabeth K. Hanson, Ph.C.

Department of Special Education & Communication Disorders
University of Nebraska
Lincoln, Nebraska

Kathryn M. Yorkston, Ph.D.

Department of Rehabilitation Medicine
University of Washington
Seattle, Washington

David R. Beukelman, Ph.D.

University of Nebraska Medical Center
Omaha, Nebraska

This systematic review of the literature addresses the use of speech supplementation techniques for speakers with dysarthria and 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 19 articles related to speech supplementation, a group of strategies that provide additional information to the speech signal to help communication partners understand unintelligible speech. Strategies include *alphabet supplementation*, in which the speaker indicates the first letter of the word spoken; *topic supplementation*, in which the speaker indicates the topic of the message; and *gestures* accompanying and illustrating speech. A review of this literature suggests that speech supplementation strategies may be useful for speakers with severe or profound dysarthria, regardless of medical diagnosis or type of dysarthria. Selection among the various strategies must be made on an individual basis because each strategy has unique advantages and disadvantages. Some strategies may have the benefit of improving speech production, especially in cases where rate reduction is an appropriate target for intervention. Listeners play a critical role in ensuring the successful use of strategies. Directions for future research are provided.

One of the primary goals of speech intervention for speakers with dysarthria is to improve communicative function by increasing speech intelligibility. Improved speech intelligibility can be accomplished in at least two ways. First, the adequacy of speech production can be improved. Often this in-

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volves focusing on the physiological aspects of speech. Practice guidelines have recently been developed for management of velopharyngeal dysfunction (Yorkston et al., 2001) and respiratory-phonatory dysfunction (Spencer et al., 2002; Spencer, Yorkston, & Duffy, 2003). Lindblom (1990) refers to the acoustic signal as, "the tip of the iceberg" (p. 228) because communication is built around information *shared* by the speaker *and* the listener. The current review focuses on a second way of improving function—by providing listeners with extra information to assist them in understanding distorted speech. This supplemental information typically involves signal-independent information about the context of the message (Yorkston, Strand, & Kennedy, 1996). Speech supplementation comprises several different techniques to augment the speaker's natural speech: (1) *Alphabet supplementation*, a strategy in which the speaker provides orthographic information to listeners by identifying the first letter of each word (on an alphabet board or a forward-facing screen) just before each spoken word. (2) *Semantic or topic supplementation*, a strategy in which the topic of a message or a series of messages is provided to listeners just before the message(s) is spoken. The traditional form of topic context is a cue word or phrase that provides information about the intended meaning of an utterance or the intent of the speaker. (3) *Gestures (illustrators)*, movements directly tied to speech that serve to represent visually what is spoken verbally. See Garcia and Cannito (1996a) for a review. (4) *Syntactic supplementation*, information about the grammar or the word class (e.g., noun, verb, adjective) associated with each word spoken.

Supplemental cues can be justified from a theoretical perspective. For example, the model of mutuality (Lindblom, 1990) describes the relationship between severity of dysarthria and the importance of contextual cues. If signal information is rich (high speech intelligibility), then function is high even in the face of little contextual information. However, as the richness of the information from the acoustic signal is degraded, as in severe dysarthria, contextual information (signal-independent information) becomes more critical for maintenance of function. Clinical experience also suggests the importance of supplemental cues (Garcia & Cannito, 1996b; Hustad, 1999; Vogel & Miller, 1991; Yorkston, Strand et al., 1996). The purpose of this systematic review is to extend the theoretical perspective and clinical impressions by reviewing the evidence from the growing body of research literature related to the effect of speech supplementation on dysarthric speech.

METHODS

This 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). The following electronic databases were searched: PsycINFO covering 1,300 journals (1987 to January, 2003), MEDLINE covering 4,600 journals (1966 to January, 2003), and CINAHL covering 1,175 sources (1982 to January, 2003). Initial searches were keywords paired with the term *dysarthria*, for example, "supplementation," "first letter," "word," "cues," "intelligibility," and "comprehensibility." In addition to these electronic searches, hand searches of relevant edited books in the field of dysarthria and ancestral searches of extant references (e.g., studies cited within an article or chapter) were conducted. The general search on the topic of dysarthria yielded 2,199 references (MEDLINE). From this large search, references related to speech supplementation strategies were obtained and reviewed by two authors (EKH and KMY). Studies to be included were defined as those that reported data on supplementation for speech for at least *one person* with *dysarthria*. Thus, articles were excluded that referred to speech supplementation for people whose speech was unintelligible due to hearing impairment or other disorders and articles that provided only general descriptions of speech supplementation strategies.

A Table of Evidence (Table 1) was constructed that lists the studies in chronological order of publication. In addition to the primary focus of each study, the table contains select subject descriptors indicating the number of speakers, medical diagnosis, type and severity of dysarthria, and age range. The number of type of listeners, presentation mode, and outcome measures are also included along a summary of study conclusions.

RESULTS AND DISCUSSION

A total of 19 studies of speech supplementation published from 1977 through 2002 were identified

(Table 1). This review will focus on four types of speech supplementation. Alphabet cues and semantic cues were both examined in 9 studies, gestures in 6 studies, combinations of strategies in 6 studies, and syntactic cues in 2 studies.

Speaker Characteristics

A review of Table 1 suggests that the cumulative number of different subjects (speakers with dysarthria) is small (less than 90). Even this relatively small number may overestimate actual numbers because several studies appear to have used the same subject or group of subjects across studies. Speakers with a variety of medical diagnoses participated in the studies reviewed here. The most common medical diagnoses were cerebral palsy, cerebrovascular accident (CVA), and traumatic brain injury (TBI). Other common diagnoses included amyotrophic lateral sclerosis (ALS) and Parkinson disease. Thus, medical diagnoses were associated with both acquired and developmental dysarthria, as well as various natural courses including recovering, stable, and degenerative. Speakers also represented many different types of dysarthria. The type of dysarthria was specified in 12 (63%) of the studies and included flaccid (32% of studies), mixed (32%), spastic (26%), athetoid (5%), and hypokinetic (5%). Although most of the speakers were adults, a wide age range was represented (9 to 87 years).

A review of Table 1 suggests that the severity of dysarthria was reported to range from mild to profound. This wide range of severity levels may result from the lack of consistent definitions of the various levels of severity. Because some reduction in speech intelligibility was noted in all cases, most speakers would be defined as severe or profound, using the definitions provided in Table 2. These definitions will be used throughout this article.

Speaker Tasks

For the most part, speakers read prepared sets of words and/or sentences. Stimuli came from a variety of sources including sentences constructed specifically for the study or published lists of words or phrases (Kalikow, Steven, & Elliot, 1977; Nilsson, Soli, & Sullivan, 1994; Yorkston, Beukelman, & Tice, 1996). Exceptions were studies by Crow and Enderby (1989), where speakers named or described pictures and participated in a conversation, and Dowden (1997), where children named pictures. The amount of practice or training in use of the strategies was not typically specified. Only six of the 19 studies (31%) provided information on whether speakers had practiced using supplementation strategies. When extent of practice was discussed, it appeared that none of the speakers with dysarthria were experienced supplementation users. Rather, they were taught to use the strategy specifically for the study and did not necessarily use it in natural communication settings.

Mode of Presentation

To impose control on the experimental conditions, live conditions where interaction occurred between the speaker and listener were not used. Rather, a variety of electronic modes (audio or video) were used to present the stimuli to listeners. Video technology allows for relatively easy manipulation of the video signal to allow one image (e.g., a letter of the alphabet) to be superimposed over another (e.g., a speaker with dysarthria). It is possible to present a video stimulus of a speaker who is not using supplementation (i.e., habitual speech) and to superimpose the letter cue to provide the listener with additional information. In some cases, the alphabet or semantic cues were superimposed electronically. Seven of the 19 articles (44%) used superimposed information, and nine of the articles (56%) reported on supplementation that the speaker generated. Three of the articles did not specify how supplementation was presented to the listener. Presentation of cues under experimental conditions may inform research regarding how much information is understood from the unaltered habitual speech signal versus how much the supplemental cue adds. However, it does not closely mimic natural communication.

Listeners and Listening Task

Undergraduate or graduate level students most commonly served as listeners, although rehabilitation professionals or speech pathologists took part in three of the studies (16%). In two studies, both familiar and unfamiliar listeners participated. A total of 537 listeners took part in these studies of speech supplementation. None of the studies included the general public or nonnative speakers of American English as listeners.

Outcome Measures

The most common outcome measure, used in 13 of the studies (68%), was intelligibility measured by

TABLE 1. Table of evidence summarizing speech supplementation studies.

	Primary Focus	Number of Speakers	Medical Diagnosis	Age (yrs)	Type of Dysarthria	Severity of Dysarthria
Beukelman & Yorkston (1977)	Alphabet cues	2	TBI, brainstem stroke	17–61	Not specified	< 15% intelligible
Crow & Enderby (1989)	Alphabet cues	6	MND, CVA, PD, cerebellar degeneration	Not specified	Not specified	Mild to severe
Hammen, Yorkston, & Dowden (1991)	Semantic context	21	CP, TBI, MG, ALS, CVA	20–73	Not specified	Severe (referred for AAC evaluation)
Hunter, Pring, & Martine (1991)	Alphabet cues vs. spelling messages	8	CP	13–17	Not specified	Moderate to severe
Vogel & Miller (1991)	Top-down approaches	1	TBI	40	Flaccid	Sentence intelligibility 1%
Dongilli (1994)	Words vs. words in sentences & semantic context	8	CVA or TBI	23–87	Flaccid	Mild to profound
Beliveau, Hodge, & Hagler (1995)	Word class, alphabet, & combined cues	3	Mixed CP; TBI	25–33	Not specified	Sentence intelligibility 13-48 %
Carter, Yorkston, Strand, & Hammen (1996)	Semantic and syntactic context	6	CVA, PD, TBI, tumor	32–71	Ataxic-flaccid, ataxic, hypokinetic	Sentence intelligibility 34–82%

Speaker's Task	Number & Type of Listeners	Presentation Mode	Outcomes Measures	Study Conclusions
Reading words and short sentences	30 rehabilitation professionals	Video	Rate, intelligibility	Speaker-imposed alphabet supplementation improved sentence intelligibility. Brain stem stroke improved from 19 to 64% when aided. TBI speaker improved 33–66%.
Words (pictures), picture description, conversation	26 college students	Audiotape recording	Rate, intelligibility, phonetic transcription	Alphabet chart increased intelligibility, decreased speaking rate, and improved articulation adequacy.
Words	3 speech pathologists	Audiotape recording	Intelligibility	Semantic context improves single word intelligibility. Effects were statistically significant for all groups (profound, severe, moderate, and category size).
Test sentences	32 adults (half with and half without experience with dysarthria)	Auditory only, auditory + visual, auditory + visual with repetition, auditory + first letter	Intelligibility	For moderate dysarthria all strategies scored better than the audio-only condition. Audio + visual condition not much enhanced by repetitions or letter cues. For severe dysarthria letter cues scored better than audio + visual, repetitions, and audio alone.
Case trained to use multiple modes (drawing, gestures, speech, etc.)	40 no data reported	No data reported	Report of return to work	Alphabet supplementation, metronome, and pacing board to decrease rate not effective. Patient stimulable for top-down therapy approach. Explained rationale for intervention at pragmatic level and patient learned strategies successfully. He was able to return to work.
Reading words & sentences	96 adults without dysarthria experience from 10 to 50 years of age	Audiotape recording	Intelligibility	Words in sentences (WS) more intelligible than isolated words (IW) for mild, moderate, and severe speakers; IW more intelligible than WS for profound, semantic context increased IW intelligibility significantly severe (severe group benefited most); semantic context increased WS intelligibility significantly (moderate group benefited most), but to a lesser extent than IW.
Words	40 rehabilitation professionals	Audiotape recording	Intelligibility	Three cue condition enhance intelligibility relative to no cues; combined cues better than all others, alpha & class cues did not differ (both were different from no cue), cases differed from each other.
Sentences	36 adults ranging in age from 18–40 years	Audiotape recording	Intelligibility	Moderate group had no significant difference among no context, semantic, and syntactic context. Severe group had semantic context better than no context, syntactic context better than no context, syntactic and semantic contexts didn't differ.

(continues)

TABLE 1. *(continued)*

	Primary Focus	Number of Speakers	Medical Diagnosis	Age (yrs)	Type of Dysarthria	Severity o Dysarthri
Garcia & Cannito (1996a)	Situational context, predictive-ness, gestures, gender, familiarity of listeners	1	CVA	62	Flaccid	Sentence intelligibilit 17%
Garcia & Cannito (1996b)	Illustrative gestures, predictive-ness, and topic cues	1	CVA	62	Flaccid	Sentence intelligibility 6%
Dowden (1997)	Familiar/ unfamiliar listeners, alphabet suppl., semantic context	4	CP, dysgenesis of the cerebellum, TBI	9–19	Not specified	Severe (referred for AAC evaluation)
Garcia & Dagenais (1998)	Iconic gestures & message predictive-ness	5	CVA, ALS	37–76	Flaccid, spastic or mixed	Sentence intelligibility 10–79%
Garcia, Dagenais, & Cannito (1998)	Speech with & without gestures	1	CVA	62	Flaccid	Sentence intelligibility 6%
Garcia & Cobb (2000)	Iconic gestures	1	ALS	76	Mixed spastic-flaccid	Sentence intelligibility 28%
Hustad (2001)	Perceived effective-ness of strategies	4	CP	19–46	Mixed spastic-athetoid; spastic	Sentence intelligibility 15–25%
Hustad & Beukelman (2001)	Alphabet, topic, and combined cues	4	CP	19–46	Mixed spastic athetoid, spastic	Sentence intelligibility 15–24%

Speaker's Task	Number & Type of Listeners	Presentation Mode	Outcomes Measures	Study Conclusions
Sentences read with & without gestures	96 men & women, from 18–30 years of age	Video	Intelligibility	Gender and familiarization of the listeners were not significant variables; predictiveness and context was significant.
Sentences read with & without gestures	32, 16 men & women from 18–30 years of age	Video	Intelligibility	High predictive sentences were more intelligible than low; gestures increased intelligibility; context did not affect intelligibility.
Single words (pictures)	12 familiar and unfamiliar adults	Audiotape recording	Comprehensibility familiar & unfamiliar partners	Alphabet supplementation useful for some participants who could use alpha board and who could identify first letters. Semantic context increases intelligibility.
Sentences with & without gestures	96 men & women, from 18–30 years of age, no dysarthria experience	Video	Intelligibility	For all speakers, lowest scores with audio only presentation. Least-intelligible speakers got greatest benefit from signal independent information. Gestures not helpful for ALS subject with spinal symptoms.
Sentences read with & without gestures	NA (acoustic analysis only)	Audio portion of videotape	Intelligibility and acoustics measures (interword & sentence duration, speaking time)	IWI, speaking time, and sentence duration decreased when speaker produced low predictive sentences with gestures. For high predictive sentences, IWI and sentence duration increased slightly with gestures; mean speaking time was similar for gestures and no gestures.
Reading sentences	NA (acoustic analysis only)	Audio portion of videotape	Rate	Gestures increased the rate and decreased intelligibility in this case. Change in rate of speech, IWI, speaking time, sentence duration when gestures employed vs. when gestures not employed for the same speaker.
Sentences from narratives	68, 8 men & 60 women (mean age 21 years); no more than incidental exposure to dysarthria	Video cues superimposed	Listener rating (7-pt scale) of speaker effectiveness, willingness to communicate with & fatigue	Communicative effectiveness ratings, willingness to communicate with speakers, listener persistence in trying: all increased favorable responses with combined cue condition, mean ratings generally low.
Reading sentences	72 college students (mean age 21 years)	Digital audiovideo cues superimposed	Intelligibility	Combined cues = highest intelligibility scores, alphabet cues scores > topic cues scores, related sentences scores higher in alphabet cue condition, context has a powerful effect on intelligibility.

(continues)

TABLE 1. *(continued)*

	Primary Focus	Number of Speakers	Medical Diagnosis	Age (yrs)	Type of Dysarthria	Severity of Dysarthria
Beukelman, Fager, Ullman, Hanson, & Logemann (2002)	Habitual, clear, alphabet cues, and topic cues	8	TBI	19–45	Not specified	Sentence intelligibility 2–87%
Hustad & Beukelman (2002)	Topic, alphabet, & combined cues	4	CP	19–46	Mixed spastic-hyperkinetic, spastic	Sentence intelligibility 15–24%
Hustad & Garcia (2002)	Alphabet cues iconic gestures, and habitual speech, also semantic predictive-ness	1	CP	42	moderate-severe spastic	Moderate

ALS = amyotrophic lateral sclerosis, CP = cerebral palsy, CVA = cerebrovascular accident, MG = myasthenia gravis, MND = motor neuron disease, PD = Parkinson disease, TBI = traumatic brain injury.

TABLE 2. Definitions of levels of severity of dysarthria .

Mild	Dysarthria is noticeable but intelligibility is unaffected. Speech rate is essentially normal.
Moderate	Speech is intelligible but rate and naturalness are reduced.
Severe	Natural speech is the primary means of communication, although it is not completely understood in all situations. Speech rate and naturalness are markedly affected.
Profound	Natural speech may serve some communicative functions such as greetings or response to questions, but intelligibility is markedly reduced. Function is maintained by supplementing natural speech with other modes of communication.
Anarthric	No useful speech.

the accuracy of listener transcription of the speaker's message. Intelligibility was accompanied by measures of speaking rate or speech duration in 5 studies (26%). Comprehension, measured by asking listeners questions about a narrative produced by the speakers, was the outcome measure in 2 studies (11%). Other outcome measures, all used in a single study, were acoustic measures, phonetic transcription, listener attitudes, and an anecdotal comment about change in participation.

Results of Studies Reviewed

Conclusions of the studies summarized in Table 1 indicate consistent improvement in outcome measures with cueing in structured, experimental situations. Because many of the studies reported individual data, cross-study comparisons are possible and are reported for alphabet and semantic cues in the following section. Gestural cues are not included in this cross-study comparison because of the

Speaker's Task	Number & Type of Listeners	Presentation Mode	Outcomes Measures	Study Conclusions
Reading sentences (HINT)	10, not specified	Digital video	Rate & intelligibility	Alphabet supplementation produced higher mean intelligibility score than habitual (33% difference), clear (8.1% difference), or topic (15.9% difference). In addition, alphabet supplementation decreased mean speaking rate.
Reading narrative passages	72 college students (mean age 21 years)	Digital audio-video	Comprehension	Highest comprehension scores from combined cue condition. Lowest comprehension scores from no cue condition. Analogous to intelligibility findings in Part 1. Alpha better than topic for related sentences No difference between topic and alpha for unrelated sentences.
Sentences with & without gestures	24 women (mean age: 20.6 years)	Digital audiovideo	Intelligibility	Both alphabet supplementation and iconic gestures significantly improved intelligibility (with a similar magnitude increase). High predictive sentences were more intelligible than low predictive sentences.

small number of subjects reported. Three of the six studies focusing on gestures were case reports involving the same speaker. Caution is warranted in interpreting the following cross-study comparison because methods for measuring intelligibility along with type and severity of dysarthria vary from study to study.

Alphabet Cues

Alphabet cues may function in at least two ways. First, the identity of the first letter of the word narrows the range of possible words and, second, the strategy encourages the speaker to separate words, another potential benefit to the listener. To estimate the magnitude of benefits gained from alphabet cues, data from individual subjects were compiled across studies. Six studies reported data for individual speakers (Beliveau, Hodge, & Hagler, 1995; Beukelman, Fager, Ullman, Hanson, & Logemann, 2002; Beukelman & Yorkston, 1977; Crow & Enderby, 1989; Hustad & Buekelman, 2001; Hustad & Garcia, 2002). Data were reported on word intelligibility for 11 speakers and sentence intelligibility for 21 speakers (see Table 3). Figure 1 illustrates word intelligibility habitually (without cues) and with alphabet cues for 11 speakers with dysarthria. Note that alphabet cues increased intelligibility for all speakers (mean gain = 11.3%; range 5–25%). Figure 2 illustrates sentence intelligibility habitually (without cues) and with alphabet cues for 21 speakers with dysarthria. Note that alphabet cues increased intelligibility for all speakers (mean gain = 25.6%; range 5–69%). The most improvement was noted for the more severely involved speakers; however, greater variability was also noted in this severity range.

Semantic Cues

The information provided by semantic or topic cues may serve as a preparatory set for listeners, thereby helping them to anticipate and/or narrow expectations for the content of the forthcoming message (Hustad & Beukelman, 2000). To estimate the magnitude of benefits gained from semantic cues, data from individual subjects were compiled across studies. Six studies reported data for individual

TABLE 3. Word and sentence intelligibility scores with and without alphabet cues for individuals.

		Words			Sentence		
Reference	**Subject**	**No Cue**	**Alphabet Cue**	**Gain**	**No Cue**	**Alphabet Cue**	**Gain**
Beukelman & Yorkston (1977)	1	12	24	12	16	64	48
	2	8	25	17	33	66	33
Crow & Enderby (1989)	1	19	29	10	75	93	18
	2	44	69	25	88	99	11
	3	26	34	8	68	93	25
	4	2	10	8	25	38	13
	5	89	98	9	95	100	5
	6	11	16	5	5	24	19
Beliveau, Hodge, & Hagler (1995)	1	12	26	14			
	2	1	6	5			
	3	6	17	11			
Hustad & Beukelman (2001)	1				15	37	22
	2				11	34	23
	3				30	44	14
	4				19	33	14
Beukelman et al. (2002)	1				2	52	50
	2				2	32	30
	3				7	76	69
	4				43	66	23
	5				50	77	27
	6				62	87	25
	7				63	92	29
	8				87	100	13
Hustad & Garcia (2002)	1				31	58	27
Mean		**20.9**	**32.2**	**11.3**	**39.4**	**65**	**25.6**

speakers (Beukelman et al., 2002; Carter, Yorkston, Strand, & Hammen, 1996; Dongilli, 1994; Dowden, 1997; Hammen, Yorkston, & Dowden, 1991; Hustad & Buekelman, 2001). Data on word intelligibility for 33 speakers and sentence intelligibility for 26 speakers are reported in Table 4. Figure 3 illustrates word intelligibility without cues and with semantic cues for 33 speakers with dysarthria. Note that semantic cues increased word intelligibility for all speakers (mean gain = 28.1; range 3–48%). Largest gains were noted in the midrange of severity. Figure 4 illustrates sentence intelligibility habitually (without cues) and with semantic cues for 26 speakers with dysarthria. Note that semantic cues increased intelligibility for all speakers (mean gain = 10.7%; range 0–52%), but these gains were generally small.

Limitations in Interpreting the Experimental Studies

For the experimental studies reviewed here, intelligibility of words and sentences improved for all speakers regardless of cueing strategy. For alphabet cues, sentence intelligibility improved (mean gain 25.6%) more than word intelligibility (mean gain 11.3%). Word intelligibility improved for semantic cues (mean gain 28.1%) more than sentence intelligibility (10.7%). The amount of benefit varied considerably from speaker to speaker, with the

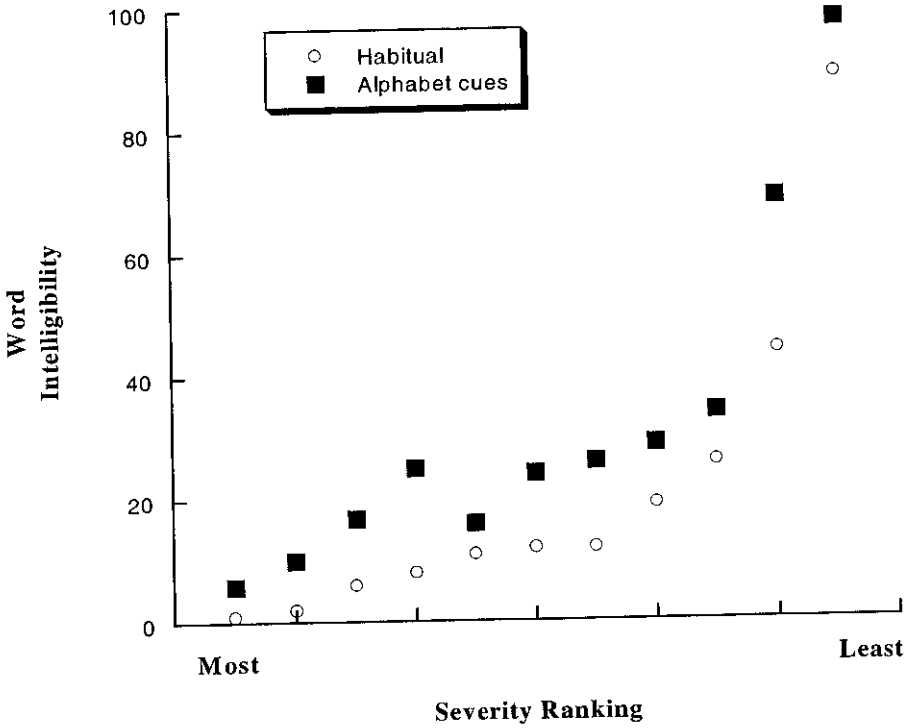

Figure 1. Word intelligibility without cues (habitual) and with alphabet cues for speakers with dysarthria rank ordered by habitual intelligibility scores.

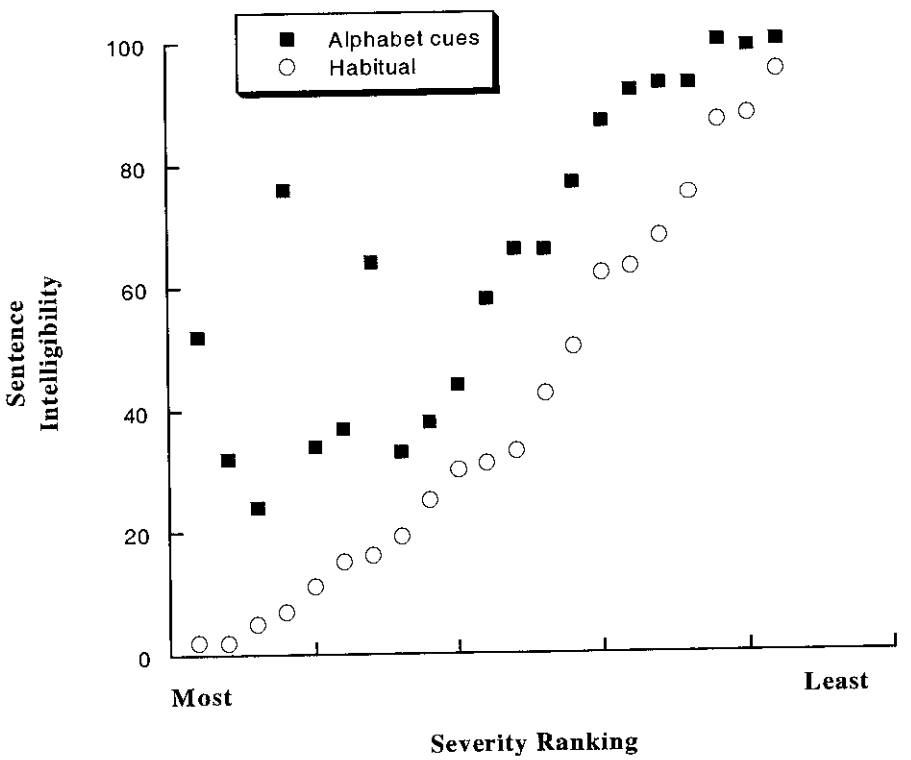

Figure 2. Sentence intelligibility without cues (habitual) and with alphabet cues for 21 speakers with dysarthria rank ordered by habitual intelligibility.

TABLE 4. Word and sentence intelligibility scores with and without semantic cues.

		Words			Sentence		
Reference	**Subject**	**No Cues**	**Semantic Cues**	**Gain**	**No Cues**	**Semantic Cues**	**Gain**
Hammen et al. (1991)	1	0	9	9			
	2	0	18	18			
	3	1	7	6			
	4	1	17	16			
	5	2	18	16			
	6	4	25	21			
	7	3	14	11			
	8	3	22	19			
	9	7	42	35			
	10	9	40	31			
	11	15	53	38			
	12	15	59	44			
	13	17	48	31			
	14	25	67	42			
	15	25	62	37			
	16	35	76	41			
	17	43	81	38			
	18	53	86	33			
	19	60	93	33			
	20	66	93	27			
	21	83	97	14			
Dongilli (1994)	1	0	30	30	0	8	8
	2	5	31	26	0	1	1
	3	45	76	31	63	70	7
	4	40	88	48	77	84	7
	5	52	80	28	69	86	17
	6	54	93	39	82	98	16
	7	72	96	24	98	98	0
	8	95	98	3	99	99	0
Carter et al. (1996)	1, 2, 3,				72	75	3
	4, 5, 6				29	38	9
Dowden (1997)	1	20	60	40			
	2	10	46	36			
	3	20	60	40			
	4	4	25	21			
Hustad & Beukelman (2001)	1				15	24	9
	2				11	21	10
	3				30	37	7
	4				19	32	13

TABLE 4. *(continued)*

Reference	Subject	Words			Sentence		
		No Cues	Semantic Cues	Gain	No Cues	Semantic Cues	Gain
Beukelman et al. (2002)	1				2	5	3
	2				2	5	3
	3				7	59	52
	4				43	53	10
	5				50	55	5
	6				62	96	34
	7				63	74	11
	8				87	97	10
Mean		**26.8**	**54.8**	**28.1**	**44.5**	**55.2**	**10.7**

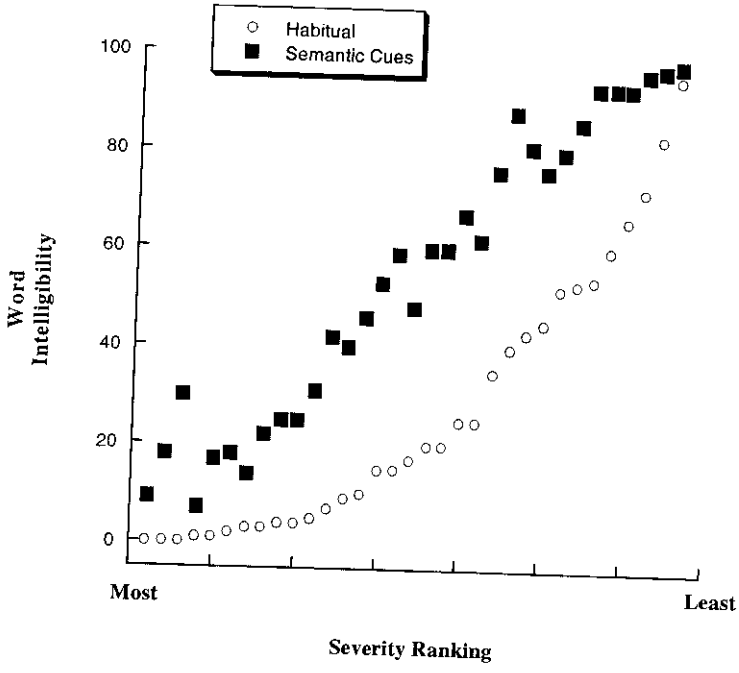

Figure 3. Word intelligibility without cues (habitual) and with semantic cues for 33 speakers with dysarthria rank ordered by habitual intelligibility scores.

greatest variability and benefit in speakers with more severe dysarthria. The studies examined in this review provide useful information that suggests a strong, consistent benefit of various cueing strategies and give some support to ideas about why the strategies work. However, a number of limitations prevent broad generalization to natural communication environments. These limitations are outlined below.

Lack of spontaneous speech. Most of the studies imposed a variety of controls on communication that are not typically found in natural settings. For example, speakers often produced utterances that had been prepared for them, thus the speech does not represent spontaneous utterances.

Practice with supplementation. For the most part, speakers appeared to have little practice or training with the strategies. Communication in any

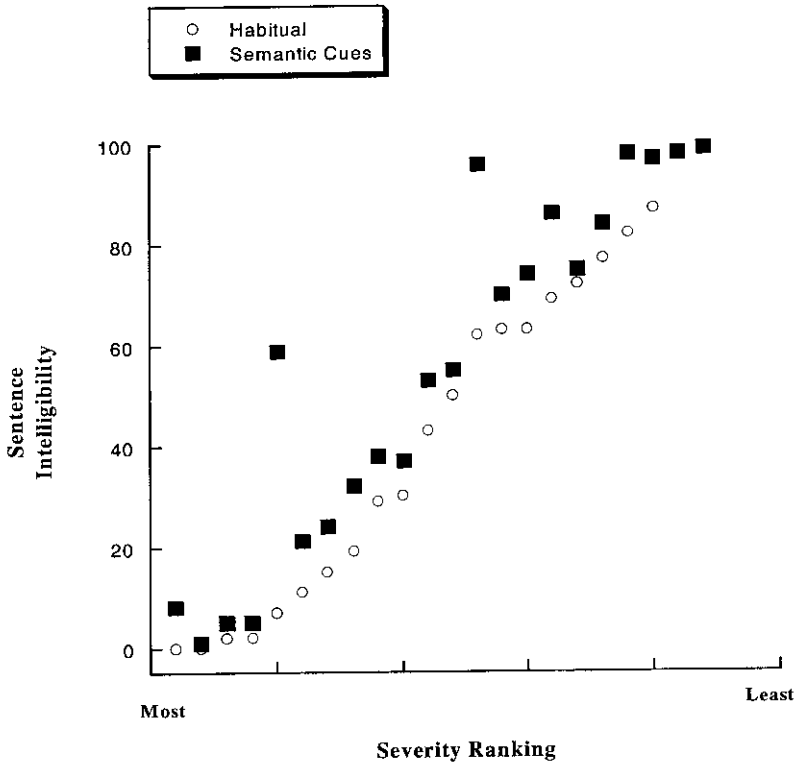

Figure 4. Sentence intelligibility without cues (habitual) and with semantic cues for 26 speakers with dysarthria.

mode improves with practice. Whether speakers are practiced in the use of speech supplementation may influence the intelligibility of their speech.

Lack of live interactions. The mode of presentation of the utterance to the listener was either audio or video recording. Thus, live interactions between the speaker and listener were not examined.

Acceptance of supplementation. Few of the studies focused on speaker or listener attitudes toward supplementation. At most, attitudes were documented by having participants view video recordings of speakers with dysarthria and then rate their attitudes. Caution is warranted in generalizing the reactions of participants viewing a TV monitor to potential communication partners in actual conversational settings.

Superimposed versus speaker-imposed. Finally, some of the studies used letter or word cues that were superimposed over habitual speech (using video-editing techniques), whereas in other studies the speakers were physically pointing to the letters or words. It was not always clear whether the supplementation was superimposed or speaker imposed. This discrepancy makes it difficult to interpret findings because it is likely the stimuli that included speaker-imposed supplementation altered the acoustic signal by slowing rate, in addition to providing contextual information.

CLINICAL IMPLICATIONS

Despite these limitations, results of these studies have a number of clinical ramifications that are discussed in the following section. The following section presents the clinical implications of studies of speech supplementation by posing a series of questions that assist clinical decision making. Answers to the following questions cannot be drawn directly for data in the literature, rather the answers represent clinical opinion that is consistent with evidence in the research literature.

Who Is a Good Candidate for Speech Supplementation?

Individuals with many different medical diagnoses and types of dysarthria have been shown to benefit from speech supplementation strategies. Thus,

medical diagnosis and type of dysarthria do not appear to be critical determiners of successful strategy use. Unlike type of dysarthria, severity of dysarthria is important in selection of appropriate candidates. Although speakers with speech intelligibility scores over 80% may receive some benefit in increased intelligibility scores, the reduction in speaking rate and naturalness that accompanies use of strategies may be unacceptable to them or their communication partners. For speakers with severe or profound dysarthria, supplementation may be beneficial, if intelligibility can be increased to a functional range. Speakers with severe or profound dysarthria appear to be the best candidates for speech supplementation. Some individuals with profound dysarthria may have such limited speech that they do not benefit from supplementation.

Cognition must also be considered when identifying appropriate candidates. Use of speech supplementation strategies in natural settings imposes some cognitive demands on the speaker not imposed during ordinary speaking activities. These include the demands of selecting and indicating the alphabet or topic cue, tolerance for using a one-word-at-a-time speech style for alphabet cueing, and skills to manage or train unfamiliar communication partners. Intact pragmatic language skills are critical for speakers to use supplementation effectively. Clinical experience suggests that individuals with intact cognition have few problems meeting these cognitive demands. However, either speaker or partner training may be needed for some speakers with reduced cognitive function.

All of the strategies reviewed here involve some level of motor function to select the letter or topic or to perform the gesture. Thus, the techniques are most appropriate for individuals who have sufficient motor function to perform these activities easily. In some circumstances, an individual can use a light beam to identify the first letter or topic to supplement natural speech.

Although speaker and listener acceptance of supplementation strategies indirectly influences the use patterns of speech supplementation, most of the speaker and listener participants in the literature had no prior experience with supplementation. Therefore, caution is warranted in drawing direct implications from the research literature because attitudes before training may not accurately reflect attitudes toward supplementation after appropriate training and experience with the techniques in natural settings.

In summary, speech supplementation strategies may be considered for speakers with severe or profound dysarthria, regardless of medical diagnosis or type of dysarthria. The best candidates exhibit dysarthria that interferes with communication function in natural settings, have adequate pragmatic and cognitive skills, and have sufficient motor function to generate the cues.

What Strategy Is Best?

Each of the speech supplementation strategies has both advantages and disadvantages. Clinical decision making involves weighing the cost versus benefits of each strategy. For example, alphabet cueing can be used to communicate any message regardless of content. If the message is not understood, the alphabet board is available so that the speaker may spell the message letter by letter to resolve the communication breakdown. For some, speech production is improved. Alphabet cueing requires little training and is a low-cost alternative. Despite these advantages, alphabet cueing has a number of disadvantages in that it slows speaking rate and may disrupt prosody. Listeners must take an active role in constructing the message. They must watch as letters are indicated and repeat each word as the speaker produces it. The listener may view this interaction pattern as unnatural. An external board or keyboard device must be present.

Illustrative gestures have the advantage that an external device is not required. Because they are a part of many conversations, listeners may view them as more natural than other types of cueing. For some speakers, prosody may be improved. The disadvantage of gestures is that not all messages have a corresponding illustrative gesture. Resolving communication breakdowns may be difficult with gestures, thus an alternative mode such as an alphabet board may be required for this function. Like other supplementation strategies, adequate upper extremity function is needed.

The advantages and disadvantages of semantic cueing vary depending on how the cues are delivered. For some, frequently occurring topics are listed on the side of an alphabet board. Although this approach gives easy and quick access to the topics, not all topics can be listed. Others may introduce a topic by spelling out a key word. The advantage of this approach is that any topic may be introduced; the disadvantage is that extra time is needed to spell the word.

Some studies indicate that multiple cues result in improved outcomes as compared with single cues or habitual (natural) speech (Beliveau et al., 1995; Dowden, 1997; Hustad, 2001; Hustad &

Beukelman, 2001, 2002). Although combined cues provide extra benefit to the listener, they may also place extra cognitive and motor demands on speakers. In addition they may produce a slower rate than single cues. The advantages and disadvantages of combined cues warrant further investigation.

In summary, practical advantages and disadvantages occur for each speech supplementation strategy. In addition, evidence from experimental studies suggests considerable speaker-to-speaker variability in extent of the benefit. Together, this suggests that selection of strategies or combinations of strategies must be made on an individual basis in the clinical setting.

How Much Change Can Be Expected?

The question of how much change to expect is a difficult one to answer. If one relies strictly on the evidence from the experimental studies, one might speculate that on average a speaker might expect a gain of 25% in sentence intelligibility when a listener is provided with alphabet cues. Closer inspection of these data suggests a large range of potential gain (from 5 to 70% improvement). Caution must also be exercised in translating this evidence into clinical practice because the conditions reported in the experimental studies may not reflect the gains that could be expected in natural communication settings. In clinical practice, we must consider a "range of intelligibility potentials" for a particular speaker, depending on a number of factors, including the physical setting, listener familiarity, nature of the linguistic message, motivation, effort level, and so on (Kent, Miolo, & Bloedel, 1994 [pp. 81–82] cited in Dowden, 1997).

Another related and important question is how large of a change is needed to be functionally important? Again, this is a difficult question because the answer at least in part depends on the severity of the dysarthria. A gain of 20% may be functionally important for a speaker whose habitual intelligibility is 75% because it would result in functional speech (95% intelligibility). The same 20% gain may not be important for the severely involved speaker who moves from 5 to 25% intelligible. Most listeners attempting to communicate with someone who is 25% intelligible find it to be a difficult task. Goosens' and Crain (1986) recommended that a minimum increase of 20% or greater in intelligibility scores compared with no-cues would be required for the improvement to be considered clinically significant. Beliveau et al. (1995), however, suggest that these guidelines may be too conservative for speakers with low levels of intelligibility. Others have suggested that gains must be examined in terms of whether they move speakers into the range of functional communication rather than considering some absolute number (Beukelman et al., 2002). The main criterion is that the improvement must be judged in terms of function by the speaker and listeners. Treatment efficacy (i.e., benefit under ideal conditions) is typically measured by increases in intelligibility. However, other measures may carry more ecological validity, such as expanding the number of potential communication partners or expanding the communicative situations in which the speaker is able to participate.

In summary, there are a variety of potential measurements of change in dysarthric speech through supplementation. While intelligibility is an important basic measure of change, other outcome measures (i.e., benefit under average conditions) should be used and documented to further understand the significance of the changes effected by speech supplementation.

Does Speech Production Change?

Most of the studies examined in this review focus on changes in listener performance by measuring changes in speech intelligibility or comprehension. These changes in listener performance may be the result of at least two factors: (1) the extra information provided by the cueing strategy or (2) improved speech production. Some studies (Beukelman & Yorkston, 1977; Crow & Enderby, 1989; Garcia & Cobb, 2000; Garcia, Dagenais, & Cannito, 1998) report changes in speech as the result of strategy use. For example, one of the speakers reported by Beukelman and Yorkston (1977) improved with supplemented speech as compared with habitual speech when pointing to initial letters with the alphabet board concealed from the listener. In other words, speech intelligibility improved even when listeners were unable to see the cues. Crow and Enderby (1989) reported increased articulatory accuracy as measured by phonetic transcription when speakers used alphabet supplementation. Garcia et al. (1998) found acoustic changes in a speaker who used natural gestures. Not all reports of changes in speech were positive. Use of gestures had the negative effect of increasing rate and reducing sentence intelligibility for a speaker with ALS (Garcia & Cobb, 2000). With some noted exceptions, speech supplementation appears to have a beneficial effect on speech produc-

tion. This improvement in speech production is most likely to occur in cases where rate reduction is an appropriate target for intervention.

What Role Does the Listener Play in the Communication Process?

When implementing speech supplementation strategies, listeners play the active role of integrating information from multiple sources to interpret the message. Consensus exists that listeners are critical to successful communication with speakers with severe dysarthria. Early reports identified listener skills and experience as potentially important factors (Hunter, Pring, & Martine, 1991; Vogel & Miller, 1991). Later studies have begun to systematically examine the performance and attitudes of the listener (Carter et al., 1996; Dowden, 1997; Garcia & Cannito, 1996a; Hustad, 2001). Results suggest that listeners prefer multiple cues. Hustad (2001) found that unfamiliar listeners rated speaker effectiveness higher, and rated themselves as more willing to interact and more persistent when supplemental cues were provided than when no cues were provided. Attitudes were least positive with no cues and most positive when combined cues (both alphabet and topic cues) were provided. Thus, in the face of communicative challenges, listeners appeared to prefer multiple sources of information.

Listener familiarity or amount of experience is another critical variable. Studies suggest that partners familiar with the speaker with severe dysarthria understand more than do individuals with general familiarity with dysarthria (e.g., rehabilitation professionals) or inexperienced individuals (Hunter et al., 1991). These advantages are maintained when supplemental cues are added. Familiarity effects, however, do not generalize to listeners who are initially inexperienced but then familiarized with severely dysarthric speech, such as listener participants in a research study (Garcia & Cannito, 1996a; Hunter et al., 1991). Thus, extensive contact, such as daily, face-to-face interaction with speakers with severe dysarthria, results in improved ability to understand distorted speech. Thus far, attempts to provide general familiarization of dysarthric speech in experimental conditions has not resulted in important gains in listeners' abilities to understand.

In summary, listener skills, attitudes and experience contribute in important ways to the "range of intelligibility potentials" for speakers with severe dysarthria. Listeners must be viewed as an active participant in the message construction process. Therefore, information and training is critical. Clinical information might come in the form of comparisons of their performance with less familiar partners. Because familiar listeners may underestimate the problems that less experienced listeners encounter, such information should be provided as part of the clinical decision-making process that leads to the selection of speech supplementation strategies (Hustad & Beukelman, 2000). The topic of listener training will be discussed in the following section of future research directions.

SUMMARY OF CLINICAL IMPLICATIONS

Speech supplementation strategies may be useful for speakers with severe or profound dysarthria, regardless of medical diagnosis or type of dysarthria. The best candidates exhibit dysarthria that interferes with communication function in naturals settings, have adequate pragmatic and cognitive skills, and have sufficient motor function to generate the cues. Selection among the various strategies must be made on an individual basis because each strategy has unique advantages and disadvantages. Strategies are best when gains are sufficiently large to move speakers into a functional range of speech intelligibility. Some strategies may have the benefit of improving speech production, especially in cases where rate reduction is an appropriate target for intervention. Listeners play a critical role in ensuring the successful use of strategies. Therefore, sound clinical practice dictates that the attitudes and skills of frequent communication partners are considered. Listener training should be included as an important element of intervention.

FUTURE DIRECTIONS

The World Health Organization model of outcome research (1975; Robey & Schultz, 1998) provides a framework for assessing the current status of research related to speech supplementation. The studies examined in this review reflect the initial phases of clinical outcome research (Phases I and II). Specifically, brief "treatments" have been provided to a small number of subjects for whom other treatments have been unsuccessful. Thus, it is now possible to describe broadly a target population. Testing protocols have been established and outcome measures are beginning to be investigated or developed. Studies have begun to examine not only speech intelligibility but also improved speech

production associated with cueing strategies. Finally, explanations of why speech supplementation works have begun to appear. Considerable progress has been made; however, much work remains to be done. The following is a discussion of some potential future research directions.

Speech Supplementation in Natural Communication Settings

The majority of studies reviewed in this report were experimental investigations conducted under controlled conditions. Speakers with dysarthria were typically audio- or video-recorded as they produced prepared utterances, which later were presented to the listeners. There is an urgent need to investigate speech supplementation strategies in more natural communication situations. The following are examples of this type of research.

- Use of strategies in a dynamic interaction paradigm where an interchange occurs between the speaker with dysarthria and a listener. This paradigm may more closely predict performance in natural settings than the transcription tasks used in the majority of studies to date.
- Qualitative studies of the experiences of speakers with dysarthria and their communication partners as various cueing strategies are introduced.
- Measurement of patterns of strategy use in natural settings with ratings of acceptability from both speakers and their frequent communication partners.
- Studies that develop and evaluate methods of measuring success of strategy use in natural settings.

Better Understanding of the Mechanisms of Effect

Hypotheses have been formulated that speculate why various supplementation strategies work. More well-controlled experimental investigations are needed to confirm these hypotheses or develop new ones. The following are examples of this line of research:

- Studies of change in speech production associated with the supplementation strategies.
- Studies that attempt to parcel out the benefit to the listener of various "top-down" versus "bottom up" cues.
- Variability exists both among speakers and listeners. What accounts for the greater impact for some speakers than others? What accounts for better performance of some listeners?

Clear Guidelines About How the Strategies Can Best Be Applied

Because little effort has been focused on use of the strategies in settings other than the experimental conditions, research is needed to explore various applications of the strategies. The following are potential questions for this line of inquiry:

- Can alphabet supplementation be used as an exercise to practice better speech production? For example, would it help speakers learn to reduce their speaking rate?
- In what natural communication situations do speakers with severe dysarthria find speech supplementation most useful?
- In what natural communication situations do speakers with moderate dysarthria find speech supplementation most useful?
- How can supplementation strategies be integrated into augmentative communication systems?
- How can the strategies be modified across the age span from children through elderly speakers?
- What factors influence compliance in using supplementation strategies when they are indicated?

Better Guidelines for Assessment and Training

Results of the current review suggest some general guidelines for candidacy involving primarily the severity of dysarthria. Better descriptions of procedures for assessment and training are needed. The following questions may provide clarification.

- What cognitive demands are inherent in various supplementation strategies?
- How can these demands be assessed? How can training programs help meet these demands?
- Does communication improve with speaker and/or listener training in use of the strategies?
- What is the most effective way to teach the use of multiple strategies or strategy shift-

ing in response to various communication situations?
- How can unfamiliar listeners be trained so that their performance approximates more closely the performance of familiar listeners?

Better Outcome Measures

The studies reviewed in this report relied heavily on a small number of outcome measures, most commonly speech intelligibility. Clearly, other outcome measures are needed, especially as investigations begin to focus on communication in natural settings where transcription of speech intelligibility is not a practical outcome measure. The following are examples of possible research questions:

- What is the relationship between severity of dysarthria as measured by speech intelligibility and perceived function in natural settings?
- How do speakers' estimates of their own communication effectiveness relate to speech intelligibility measures?
- How much gain in intelligibility is needed before listeners perceive a benefit?
- What is the relationship between intelligibility (listeners' ability to understand words produced by the speaker with dysarthria) and comprehension (listeners' ability to draw meaning from the communicative exchange)?
- Is comprehension a better predictor of performance in natural settings than intelligibility?
- What measures best reflect the speaker's experience in natural communication settings?
- How can changes in the level of participation be assessed?

Focus on Communication Partners

Because communication partners play an active role in the construction of messages when interacting with speakers with severe or profound dysarthria, more information is needed about them. Asking questions such as the following may help.

- Are communication partners used in the current studies (often college students) typical of the frequent communication partners of speakers with severe dysarthria?
- What are the attitudes of communication partners to various supplementation strategies?
- Are there important differences among communication partners? If so, what variables are associated with better communication partners? With poorer communication partners?
- How do communication partner estimates of communication effectiveness compare to those of the speakers with dysarthria?
- Do communication partners for whom English is not a first language do more poorly than native speakers in understanding severe dysarthria?

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Address correspondence to Kathryn M. Yorkston, Ph.D., Rehabilitation Medicine, Box 356490, University of Washington, Seattle, WA 98195-6490 USA.
E-mail: yorkston@u.washington.edu

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