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4

Integrating AAC Strategies with Natural Speech in Adults

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Communication is a multimodal process for most speakers. Communicators typically incorporate speech, gestures, facial expression, and body language into almost all communication interchanges. The simultaneous use of multiple modes of communication adds redundancy to the communicative interaction, thus increasing the listener's chance of understanding the message in the way it was intended by the speaker. Similarly, multimodal communication adds supplemental information that may enhance or clarify the intent of the message.

Multimodal communication is perhaps even more important for adults who have reduced speech intelligibility secondary to neurogenic communication disorders than it is for speakers without disabilities. For these individuals, at least one and typically more than one communication modality is compromised because of motor control problems. Augmentative and alternative communication (AAC) strategies and systems can become important components of a multimodal communication system to enhance the effectiveness of natural speech. For adults with acquired communication disorders, natural speech and multimodal communication strategies that include AAC should not be mutually exclusive choices.

For those who have the ability to use natural speech, it is unquestionably the most time-efficient and linguistically flexible mode of

communication. Many individuals who have moderate to severe speech intelligibility challenges still choose to use speech as their primary mode of communication. However, when speech is too unintelligible for listeners to understand fully, the use of speech supplementation strategies can greatly enhance listeners' contextual knowledge regarding the content of the message (Beliveau, Hodge, & Hagler, 1995; Beukelman & Yorkston, 1977; Carter, Yorkston, Strand, & Hammen, 1996; Crow & Enderby, 1989; Dongilli, 1994; Garcia & Cannito, 1996a). Examples of AAC strategies that can be used to enhance natural speech include alphabet supplementation and topic supplementation. It is important to emphasize that these strategies are used in conjunction with natural speech and are not intended to replace natural speech.

ALPHABET SUPPLEMENTATION DEFINED

Alphabet supplementation strategies combine the use of natural speech with an alphabet board. To use alphabet supplementation, the speaker points to the first letter of each word in the message as he or she speaks it (e.g., pointing to the letter *r* as the target word "rainbow" is spoken). The rationale for this strategy is that the first letter of each word provides orthographic-phonetic context supporting the individual's speech production, thereby improving the listener's ability to understand (Yorkston, Beukelman, Strand, & Bell, 1999). Alphabet supplementation strategies can be employed using a low-technology alphabet board (see Yorkston et al., 1999, pp. 509–510) or a high-technology AAC system with a display that faces the interactant, such as the LightWriter.

TOPIC SUPPLEMENTATION DEFINED

Topic supplementation strategies combine the use of natural speech with communication boards containing topic words or pictures. Typically, when a speaker uses topic supplementation strategies, he or she will indicate the topic of the message on a communication board prior to producing the message using natural speech (Yorkston et al., 1999). The rationale for use of this strategy is that the topic words or pictures provide contextual information that serves as a frame of reference for the listener, preparing him or her for the forthcoming message or messages related to the topic. Consequently, listeners should understand natural speech with a higher degree of accuracy. Like alphabet supplementation, both low- and high-technology tools can be used to provide topics to listeners.

LISTENER PROCESSING OF DYSARTHRIC SPEECH

When a speaker has reduced intelligibility, the listener must process an acoustic speech signal that may be distorted in a variety of ways. This makes the task of parsing phonetic information into lexical and sentential units different and more difficult than the same task given a typical acoustic speech signal. When intelligibility is diminished, variables in addition to the listener's acoustic phonetic knowledge and decoding ability contribute to processing of speech (Kent, 1993; Kent, Weismer, Kent, & Rosenbek, 1989). The role of skills that the listener brings to the task of decoding and understanding dysarthric speech has received little attention. Examples of listener variables include linguistic knowledge, world knowledge, and disability knowledge (Hustad, Beukelman, & Yorkston, 1998).

Mutuality Model of Communication: Intrinsic Sources of Information

In his mutuality model of communication, Lindblom (1990) dichotomized mutual understanding between speaker and listener into two components: the speech signal itself and information that is independent of the speech signal. Lindblom's model is illustrated in Figure 1.

On the vertical plane, the acoustic signal is represented as a continuum ranging from poor to rich. This dimension refers to the listener's ability to decode the speech signal in isolation, as measured by traditional intelligibility measures. The horizontal plane represents signal-independent information. Lindblom described signal-independent information as "what is in the listener's brain" (1990, p. 225), or all of the skills and characteristics that the listener brings to the communication task.

Mutuality or successful communication is conceptualized as a complementary relationship between information provided by the speech signal (i.e., signal-dependent) and information or knowledge possessed by the listener that is used to decode the speech signal (signal-independent). Lindblom emphasized that:

> Our perception of speech and other communicative events is not determined by the signal alone. It is shaped by an interaction between the signal on the one hand and information stored in our brains on the other. In fact, in communication the signal is only the tip of the iceberg. Communication is built around shared knowledge. (1990, p. 228)

Generally, Lindblom's (1990) mutuality model posited that, as the speaker's acoustic signal becomes more distorted, the listener's reliance on signal-independent or top-down intrinsic linguistic knowledge

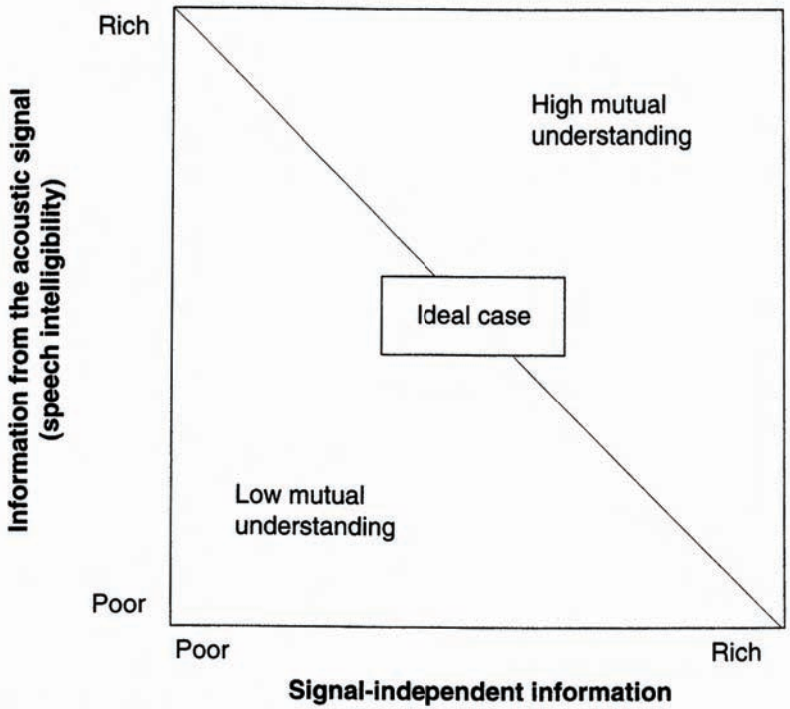

Figure 1. Mutuality of speaker–listener interaction. (From Lindblom, B. [1990]. On the communication process: Speaker–listener interaction and the development of speech. *Augmentative and Alternative Communication, 6,* 220; adapted by permission.)

becomes increasingly important. Conversely, as the speaker's acoustic signal approaches normal, the listener's reliance on acoustic phonetic information alone becomes increasingly sufficient to ensure mutual understanding between speaker and listener.

Similarly, Vogel and Miller (1991) discussed a top-down approach to dysarthria intervention. They referred to knowledge of the language that listeners possess as top-down deductive knowledge. This includes an understanding of and expectations for syntax, semantics, and pragmatics. Top-down deductive knowledge allows listeners to take available information, which may be incomplete, and construct or infer a whole.

In addition to top-down deductive knowledge, listeners possess bottom-up inductive acoustic-phonetic processing capabilities. These capabilities enable listeners to parse acoustic information into phonetic units and reconstruct the message by decoding and putting together all of the information within the acoustic signal.

Extending the Model of Mutuality to Multiple Linguistic Levels

Communication occurs at a variety of linguistic levels including words, sentences, and connected discourse. Research on speech intelligibility has shown differential effects of stimulus length. For example, words tend to be less intelligible than sentences (Crow & Enderby, 1989; Miller, Heise, & Lichten, 1951; O'Neill, 1957; Sitler, Schiavetti, & Metz, 1983). One reason for this phenomenon may be that listeners are able to apply top-down knowledge more readily to a sentence transcription task than to a word transcription task. In sentence transcription, listeners have expectations for semantic relations and syntactic structure that may enable them to decode what they hear in an interactive or parallel fashion, employing both top-down and bottom-up knowledge simultaneously. In contrast, when listeners transcribe words in isolation, they are forced to rely more heavily on acoustic phonetic information present in the stimulus word to decode because there is reduced linguistic context and therefore reduced opportunity to apply linguistic knowledge.

Little is known about discourse intelligibility compared with word and sentence intelligibility. Narrative discourse differs from isolated sentences in that meaning is cumulative, building from sentence to sentence in a cohesive, sequential fashion. As such, listeners may be able to apply top-down linguistic knowledge even more readily with discourse than with sentences. Therefore, it might be expected that discourse would be more intelligible than both sentences and words. This hypothesis is supported by preliminary studies that have examined intelligibility differences according to stimulus length.

For a speaker with severe dysarthria, Hustad (1999b) found that listeners were able to transcribe a 10-sentence narrative discourse sample with a mean intelligibility of 27%. The same listeners transcribed unrelated sentences with mean intelligibility of 6%. Finally, word intelligibility was 3%. It is interesting to note that the difference between discourse and sentential contexts was much larger than that observed for isolated word intelligibility and sentential context in this study. Figure 2 illustrates these data.

Using DECTalk synthesized speech (available from Digital Equipment Corporation), Drager (1999) compared the intelligibility of target sentences preceded by story context with sentences presented in isolation. She found that listeners were able to repeat sentences with significantly greater accuracy when story context preceded target sentences. These results support the hypothesis that listeners are more readily able to apply top-down linguistic knowledge in discourse contexts compared with sentence contexts.

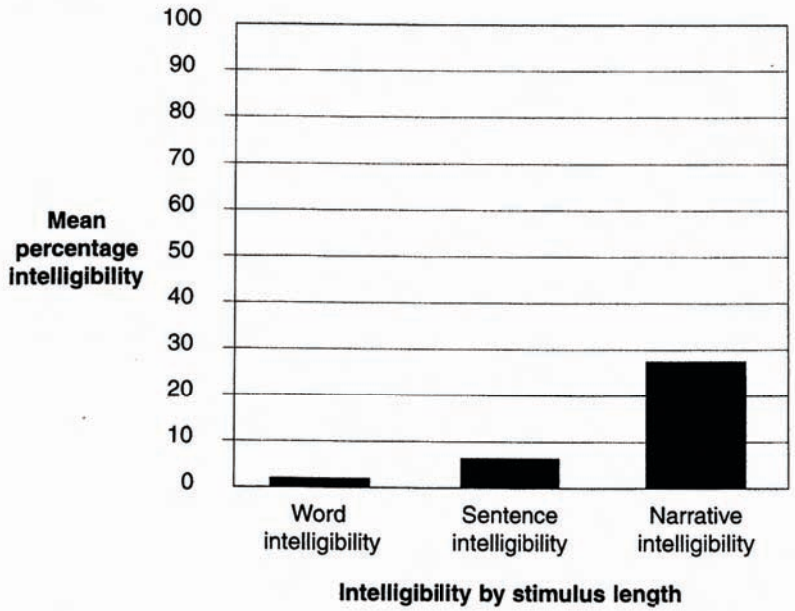

Figure 2. Effects of stimulus length on intelligibility of a speaker with severe dysarthria. (From Hustad, K.C., & Beukelman, D.R. [1998]. *Integrating residual natural speech and AAC.* Paper presented at the American Speech-Language-hearing Association (ASHA) Annual Convention, San Antonio, TX; reprinted by permission.)

Speech Supplementation Strategies: Extrinsic Sources of Information

Several studies have investigated the effects of different types of extrinsic information, such as alphabetic and topic cues, on speech intelligibility. This research has focused primarily on word- and sentence-level stimulus materials. Generally, findings have been consistent across studies, suggesting that when speech is less intelligible, listeners benefit more from extrinsic linguistic cues. There are several kinds of extrinsic linguistic cues: alphabetic cues, topic/semantic cues, combined alphabetic and topic cues, and visual and gestural cues.

Alphabetic Cues Alphabetic cues have differential effects on intelligibility according to linguistic level. This section reviews literature examining words, sentences, and discourse.

Word Intelligibility Research has demonstrated that alphabetic cues have similar effects on the word intelligibility of different adult speakers with dysarthria. Beliveau, Hodge, and Hagler (1995) obtained recordings of isolated words from speakers with moderate, severe, and profound dysarthria. Extrinsic linguistic cues were imposed on the speech samples via a videotape. Results showed that a speaker with moderately severe speech impairment showed a 14% improvement in word-level intelligibility when alphabetic cues were provided to listeners. (Mean intelligibility was 12% with no cues and 26% with alphabetic cues.) One speaker with a profound impairment showed an 11% improvement when listeners were given alphabetic cues. (Mean intelligibility was 6% with no cues and 17% with alphabetic cues.) Finally, Beliveau and colleagues found that the speaker with a severe impairment showed a 5% increase in intelligibility when listeners were presented with alphabetic cues. (Mean intelligibility was 1% with no cues and 6% when alphabetic cues were provided.)

Crow and Enderby (1989) employed a different methodology to examine the difference between alphabetic cues and no cues for word intelligibility. In their study, listeners were not provided with extrinsic information regarding the first letter of each word. Rather, recordings of speakers were obtained while each speaker used an alphabet board to point to the first letter of each word employed in the study, thus modifying the acoustic signal to increase intelligibility. Results showed that an alphabet board used concurrently with speech production modified the acoustic signal itself, resulting in increased speech intelligibility. Overall, their results showed that the use of an alphabet board increased word intelligibility by an average of 11% (with a range of 5%–25%) across speakers with dysarthria who had mild to severe impairments. Results showed that the speaker with a moderate impairment benefited most. (Intelligibility without the use of an alphabet board during production was 44%; intelligibility with an alphabet board during production was 69%.) One in three speakers with a profound impairments benefited least. (Intelligibility without the use of an alphabet board during production was 11%; intelligibility with alphabet board during production was 16%.) Overall, these results demonstrate that the use of an alphabet board enhances speech intelligibility through both provision of additional information to the listener as well as modification of the acoustic signal itself.

Sentence Intelligibility Generally, research has demonstrated that provision of alphabetic cues for each word of a sentence produced by speakers with dysarthria enhances the listener's ability to transcribe disordered speech correctly. The magnitude of the improvement, however, has varied markedly among studies, ranging from 5% to 52% compared with intelligibility when listeners are given no cues. There are a number of variables that may affect the magnitude of improvement observed. These include the severity of the speaker's dysarthria, rate of speech, interword pauses, and whether listeners are able to see the alphabet cues.

Early research by Beukelman and Yorkston (1977) demonstrated that the use of alphabet supplementation resulted in a 33% increase in sentence intelligibility for one speaker (intelligibility without alphabet supplementation was 33%; intelligibility with alphabet supplementation was 66%) and 52% for another speaker (intelligibility without alphabet supplementation was 16%; intelligibility with alphabet supplementation was 68%). Beukelman and Yorkston observed that when adults with dysarthria employed alphabet supplementation, their rate of speech was reduced. This may have provided listeners with additional processing time. In addition, Beukelman and Yorkston observed that speakers often inserted extended interword pauses when using alphabet supplementation. This may have served to help listeners identify word boundaries more clearly. In this study, increases in intelligibility could be attributed both to changes in the speech signal itself as well as to provision of extrinsic alphabetic information to listeners in this study. To confirm this finding, Beukelman and Yorkston examined sentence intelligibility of the same two speakers when sentences were produced using alphabet supplementation, and listeners were not provided with alphabetic cues during transcription. Results demonstrated that intelligibility gains for one speaker were based almost exclusively on the provision of extrinsic alphabet cues to listeners. (Habitual speech intelligibility was 16%; speech intelligibility using alphabet supplementation when listeners did not receive extrinsic alphabet cues was 19%.) However, for another speaker who had less severe communication challenges, results demonstrated that intelligibility gains were due to provision of both extrinsic alphabet cues to listeners and changes in the acoustic speech signal associated with the simultaneous activities of speaking and pointing to the first letter of each word as it was spoken. (Habitual speech intelligibility was 33%; speech intelligibility using alphabet supplementation when listeners did not receive extrinsic alphabet cues was 52%.)

Crow and Enderby (1989) demonstrated a similar effect with speakers who had dysarthria of varying severity. Their results demonstrated that sentences produced while simultaneously pointing to an alphabet board showed an average increase in intelligibility of 15% (within a range of 5%–25%), compared with speech produced in a habitual fashion. Gains shown in Crow and Enderby's study do not reflect the effects of extrinsic information provided to the listener in the form of alphabetic cues. That is, listeners did not receive any alphabetic information in this study; rather, they only *heard* speech produced while alphabet supplementation was being employed by the speaker.

Hustad and Beukelman (1998) examined the effects of extrinsic alphabetic cues on sentence intelligibility for a speaker with severe dysarthria. For this experiment, sentences were produced using habitual speech, and extrinsic alphabetic cues were superimposed on the signal during presentation to listeners. Results showed a 10% improvement for this speaker when extrinsic alphabet cues were provided (9% intelligibility without cues and 19% intelligibility when alphabet cues were provided).

Overall, it is clear that extrinsic cues provided to listeners and signal-dependent acoustic adjustments made in the speech of individuals using alphabet supplementation both contribute to increased speech intelligibility when alphabet supplementation strategies are employed. However, the independent contribution of each is unclear.

Discourse Intelligibility The effects of alphabetic cues on discourse intelligibility have received only preliminary attention. Hustad (1999) conducted a pilot study involving a speaker with severe dysarthria in which the speaker produced stimulus material using habitual speech and alphabet cues were imposed on the speech signal after the speech sample was collected. Results showed that extrinsic alphabetic cues provided to listeners increased speech intelligibility by approximately 40% compared with discourse intelligibility scores for the same stimulus material when no alphabetic cues were provided. This finding was statistically significant. See Figure 3 for a graphic illustration of these data. Research to further explore this finding is underway.

Taken together, results of alphabet supplementation studies suggest that listeners benefit from provision of additional phonetic information provided by alphabetic cues at word, sentence, and discourse levels. Comparison across studies discussed previously suggests that listeners may benefit to a somewhat greater extent when the acoustic signal is modified to increase word segmentation and to decrease rate of production concurrently with presentation of alphabetic cues (Beukelman & Yorkston, 1977). However, listeners benefit from a modified speech signal in which word segmentation is increased and rate is decreased even without the provision of alphabetic cues (Beukelman & Yorkston, 1977; Crow & Enderby, 1989). Conversely, listeners benefit from provision of extrinsic alphabetic cues when the speech signal is not modified (Hustad, 1999; Hustad & Beukelman, 1998). Clearly, provision of alphabetic cues has the potential to increase intelligibility markedly; however, additional research is necessary to determine more conclusively the relative contribution of the speech signal itself and signal-independent information.

Topic/Semantic Cues Like alphabetic cues, topic cues have differential effects on intelligibility according to linguistic level. The section reviews literature examining words, sentences, and discourse.

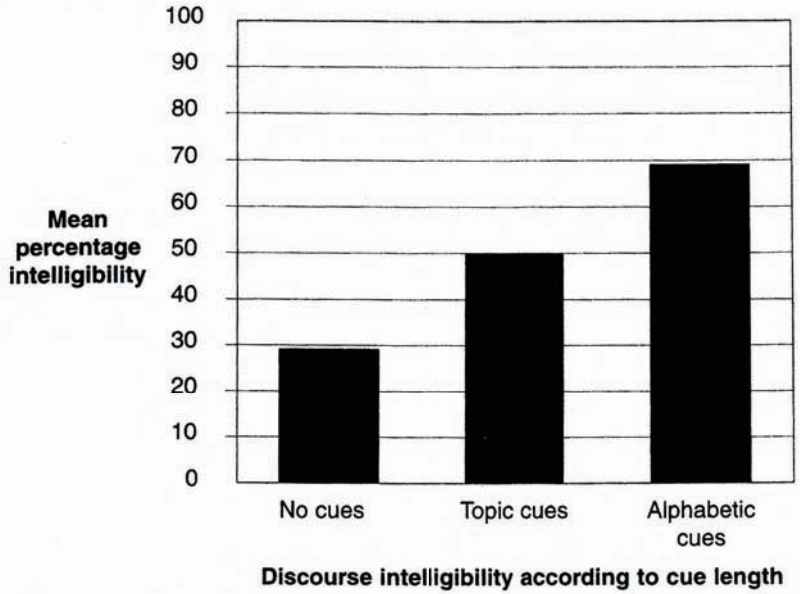

Figure 3. Effects of cues on speech intelligibility of discourse for a speaker with severe dysarthria. (From Hustad, K.C. [1999]. *Effects of context on intelligibility and comprehensibility of severely dysarthric speech* [p. 42]. Unpublished doctoral dissertation, University of Nebraska–Lincoln.)

Word Intelligibility Research examining the effects of topic cues on speech intelligibility of single words has clearly demonstrated that when listeners are provided with topic cues, intelligibility improves. Hammen, Yorkston, and Dowden (1991) studied the effects of topic cues on word-level intelligibility of adult speakers with moderate, severe, and profound dysarthria. Results showed that all speakers had increased intelligibility scores when topic context was provided to listeners. However, differential effects based on severity of speech impairment were noted. Hammen and colleagues found that topic cues benefited speakers with severe dysarthria the most. (Average intelligibility was approximately 25% when listeners did not have topic cues and 65% when listeners were provided with topic cues.) Speakers with moderate dysarthria benefited less from the provision of topic cues to their listeners. (Average intelligibility was approximately 65% when listeners did not have topic cues and 94% when listeners were provided with topic cues.) Speakers with profound dysarthria experienced the least benefit from provision of topic cues. (Average intelligibility was approximately 4% when listeners did not have topic cues and 23% when listeners were provided with topic cues.)

Dongilli (1994) examined speakers who had flaccid dysarthria of varying severity. Provision of topic cues for words resulted in increased speech intelligibility ranging in magnitude from 29% to 40% across all speakers. Results were consistent with those found by Hammen and colleagues (1991). Topic cues increased word-level intelligibility the most for speakers with severe dysarthria, followed by speakers with moderate dysarthria, and speakers with profound dysarthria experienced the least benefit from provision of topic cues.

Research by Beliveau and colleagues (1995) also revealed gains in word intelligibility when topic cues were provided to listeners for a speaker with severe dysarthria. However, their gains were of reduced magnitude compared with other research (average improvements were between 5% and 18% across all speakers). Beliveau and colleagues found that intelligibility was increased more for one speaker with severe dysarthria than for two other speakers with profound dysarthria.

Sentence Intelligibility The effects of topic cues on sentence intelligibility have received considerable attention with different populations of speakers and with different types of topic cues. Monsen (1983) examined the effects of topic setting on the sentence intelligibility of speakers with hearing impairments representing a range of severity levels. Topic cues provided for sentences were very broad in nature and consisted of the physical setting where the sentence may have been uttered (e.g., "outside"). Monsen's results showed that, overall, intelligibility of sentences increased by an average of 14% when they were prefaced with topic cues. This was significantly better than intelligibility of sentences presented without topic cues.

Dongilli (1994) examined the effects of topic cues on sentence intelligibility of adult speakers with dysarthria. Results showed that topic cues increased intelligibility for moderate, severe, and profound groups. However, the magnitude of improvement was considerably less than that noted for single-word intelligibility. Speakers with moderate challenges benefited the most from topic cues (75% intelligibility without topic cues; 92% intelligibility with topic cues). Speakers with severe challenges showed a 7% benefit (70% intelligibility without topic cues; 77% intelligibility with topic cues), and speakers with profound dysarthria showed a 4% benefit (0% intelligibility without topic cues, 4% intelligibility with topic cues).

Carter and colleagues (1996) examined sentence intelligibility among six speakers with dysarthria. Half of the speakers had moderate dysarthria, and half had severe dysarthria. Results showed that topic cues did not significantly improve the intelligibility of speakers who had moderate dysarthria. However, topic cues significantly

improved the intelligibility of speakers who had severe dysarthria by an average of 9%. Similarly, Hustad and Beukelman (1998) found that sentence intelligibility was improved by 10% for a speaker with profound dysarthria when topic cues were provided to listeners.

Garcia and Cannito (1996b) found that the sentence intelligibility of a speaker with severe dysarthria was improved only marginally when listeners were given one of two general locational cues for each utterance (e.g., "in the house," "in the yard"). They found a statistically significant improvement (5%) when contextual cues were provided compared with no cues. Two important factors may contribute to the reduced magnitude of improvement demonstrated by Garcia and Cannito (1996b) compared with other similar sentence-level intelligibility studies. First, this study examined only one speaker with severe dysarthria, thus making results somewhat less generalizable than studies examining groups of speakers. Second, the topic cues provided to listeners consisted of broad situational information that would appear to be more ambiguous in nature, thus providing listeners with less contextual information.

Several factors may affect the magnitude of improvement observed when topic cues are provided to listeners for sentence-level material. These include severity of the speech impairment and specificity of the topic cues. Clearly, additional experimental and clinical research is necessary to better understand the effects of topic cues.

Discourse Intelligibility The effects of topic cues on discourse intelligibility were examined in a pilot study by Hustad (1999a). In the same study discussed previously involving a speaker with severe dysarthria, Hustad found that the use of topic supplementation increased listeners' transcription accuracy by approximately 20% compared with discourse intelligibility scores when no alphabetic cues were provided. This finding was statistically significant. It is interesting to note that alphabet supplementation had a significantly greater effect on the speech intelligibility of this speaker than topic supplementation. These data are illustrated in Figure 3. Research to further explore this finding is underway.

Overall, research has demonstrated that the use of topic cues increases speech intelligibility at the word, sentence, and discourse level. Possible causes of discrepancies in findings may be attributed to severity of speech impairment and nature of the topic cues provided. In general, results seem to suggest that speakers with severe (Carter et al., 1996) or moderate (Dongilli, 1994) intelligibility problems benefit most from topic cues, and speakers with profound dysarthria benefit least (Dongilli, 1994).

Alphabetic and Topic Cues Little research has examined the effects of simultaneous presentation of topic and alphabetic cues on speech intelligibility. However, it might be expected that differential effects are present by linguistic level.

Word Intelligibility Only one study to date has examined the effects of simultaneous presentation of topic and alphabetic cues at the word level. Beliveau and colleagues (1995) found that the speech intelligibility of adult speakers with severe and profound dysarthria improved by an average of 18% when both topic and alphabetic cues were provided to listeners. Their results showed a differential benefit based on severity. The speaker with severe dysarthria benefited more than two speakers with profound dysarthria; however, the benefit shown for each speaker was statistically significant.

Sentence Intelligibility Few studies have examined the effects of simultaneous presentation of alphabetic and topic cues on sentence intelligibility. Hunter, Pring, and Martin (1991) attempted to study the effects of alphabetic cues on the sentence intelligibility of individuals with moderate and severe dysarthria. However, the authors provided listeners with a single context-setting word prior to presentation of each sentence in order to more closely approximate the context available in real communicative interchanges. Consequently, their results for alphabetic cues actually reflect intelligibility when both topic and alphabetic cues are provided. Overall, results showed that listeners were able to transcribe sentences in the presence of alphabetic and topic cues significantly better than when given topic cues alone. Specifically, for speakers with moderate dysarthria, the provision of topic and alphabetic cues increased intelligibility by 13% compared with intelligibility when only topic cues were provided. Speakers with severe dysarthria showed an advantage of 18% for topic and alphabetic cues.

Discourse Intelligibility No reported research has examined the effects of simultaneous cue presentation on speech intelligibility at the discourse level. Conclusions regarding the effectiveness of simultaneous presentation of alphabetic and topic cues are difficult to draw because of the paucity of research available. However, the two studies reviewed here seem to suggest that provision of two types of cues enhances speech intelligibility more than one type of cue alone. Additional research is needed to verify this conclusion.

Visual and Gestural Cues In both clinical and experimental speech intelligibility research, assessment paradigms have tended to employ the auditory signal in isolation. For questions addressing bottom-up processing of the acoustic signal, this seems appropriate. However, when top-down contributions to intelligibility are of interest, provision of visual information may be important.

The effects of visual information on the decoding of typical speech are particularly striking in a phenomenon known as the *McGurk effect*

(MacDonald & McGurk, 1978; McGurk & MacDonald, 1976). Goldinger, Pisoni, and Luce (1996) described the McGurk effect as a perceptual illusion whereby an individual is presented with incongruous visual and auditory information from a speaker. The integration of auditory and visual information results in the perception of neither the visual nor the auditory production but rather something in between.

Published studies examining the effects of visual information, gestural information, or both on word-level and discourse-level intelligibility are not available at the present time. Systematic investigation of the effects of visual-gestural cues on speech intelligibility at the sentence level have demonstrated that visual-gestural information enhances the intelligibility of speakers with dysarthria to varying extents (Garcia & Cannito, 1996a, 1996b; Garcia & Dagenais, 1998). For example, Garcia and Cannito (1996a) found that the speech intelligibility of one speaker with severe dysarthria was enhanced by an average of 25% when listeners were presented with both auditory and visual information, including illustrative gestures produced concurrently with speech. In a subsequent study, Garcia and Cannito (1998a) demonstrated individual differences among speakers for effects of gestures on speech intelligibility. Improvements in intelligibility when visual-gestural information was provided concurrently with speech ranged from 14% to 45%, with a mean increase of 27%. For the speaker with the most severe intelligibility challenges, listeners showed the greatest benefit (45% increase) from multimodal presentation. Conversely, for the speaker with the least severe intelligibility challenges, listeners benefited the least from multimodal presentation including gestures (14% increase).

The effects of visual information derived from the face of the speaker without use of illustrative body gestures are less clear. Intelligibility findings for the same speakers when listeners were presented with multimodal information in the form of simultaneous video and audio signals compared with the audio signal only yielded diverse results. Generally, intelligibility is higher when audio and video signals are presented simultaneously. However, the effects of severity of the speech impairment are inconclusive. One can manipulate the summary data presented by Garcia and Dagenais (1998) to examine the difference between speech intelligibility scores obtained through audio-only transcription and scores obtained through transcription of a simultaneous audio-video signal where speakers were not producing gestures in either condition. Data suggest that listeners benefited from multimodal presentation by an average of 12% with a range of 9%–18% across four speakers who have impairments of varying severity. Garcia and Cannito (1996b) showed that the difference between simultaneous

presentation of audio and video signals for a speaker with severe dysarthria and audio-only presentation for the same speaker were not significantly different. Although the observed difference was in favor of the multimodal signal presentation, it was only 2%.

Hunter and colleagues (1991) showed that for speakers with moderate dysarthria, multimodal presentation of speech stimuli resulted in a significant increase (17%) in intelligibility scores, compared with auditory presentation only. However, for speakers with severe dysarthria, the difference between audio presentation and multimodal (i.e., simultaneous audio and video) presentation was not significant (1% difference in favor of audio-only presentation).

Monsen (1983) examined the intelligibility of speakers with a diverse range of severity of hearing impairments. His results showed that when listeners were able to see speakers, sentence transcription scores increased by an average of 14%, compared with presentation of the audio signal alone. Although Monsen examined a range of speakers, summary data for individuals were not available, so differential effects of visual context on speech intelligibility by severity could not be determined.

Overall, results seem to indicate that gestures presented visually enhance speech intelligibility, and this effect was particularly salient for speakers with severe intelligibility challenges (25%–45% improvement). When gestural information was not provided but listeners were presented with multimodal information (i.e., they viewed the speaker producing speech), on average listeners benefit by approximately 15%. However, benefits according to severity of the dysarthria are contradictory and inconclusive. Individual differences among speakers would seem to play an important role in the presence or absence of this effect.

COMBINING INTRINSIC AND EXTRINSIC INFORMATION: AN INTEGRATED MODEL FOR AUGMENTED COMMUNICATION

Integration of AAC speech-supplementation strategies presented in the previous section along with Lindblom's (1990) model of mutuality led Hustad (1999) to develop a new model for considering the joint effects of intrinsic and extrinsic information. This model is illustrated in Figure 4. To iterate, intrinsic information includes bottom-up acoustic phonetic processing capability and top-down linguistic knowledge. Extrinsic information includes the acoustic signal provided by a speaker and any supplemental or contextual compensatory cues provided by the speaker to assist listeners.

Hustad's (1999) model can be characterized in a two-by-two matrix. Each of the four cells within this model represents different types of information that may contribute to the communication process. On the vertical axis, two types of information are represented. The first is extrinsic information available to the listener, such as the speech signal itself (also called *signal-dependent acoustic information*). The second type is explicit cues, or information that is independent of the speech signal, such as visual information conveyed by facial expressions and explicit compensatory cues (e.g., topic cues suggesting a context for the message, alphabetic cues suggesting word-initial phonemic information).

On the horizontal axis, two types of information are represented. The first is information intrinsic to the listener, such as bottom-up or phonetic decoding skills, that allow the listener to parse acoustic information into phonetic units. The second is top-down knowledge of the language, including its meaning (i.e., semantics), rules and expectations for how words are combined (i.e., syntax), and the rules for its use in social contexts (i.e., pragmatics).

Meaningful communication requires that at least two cells of this matrix be active. For example, the first cell represents availability of

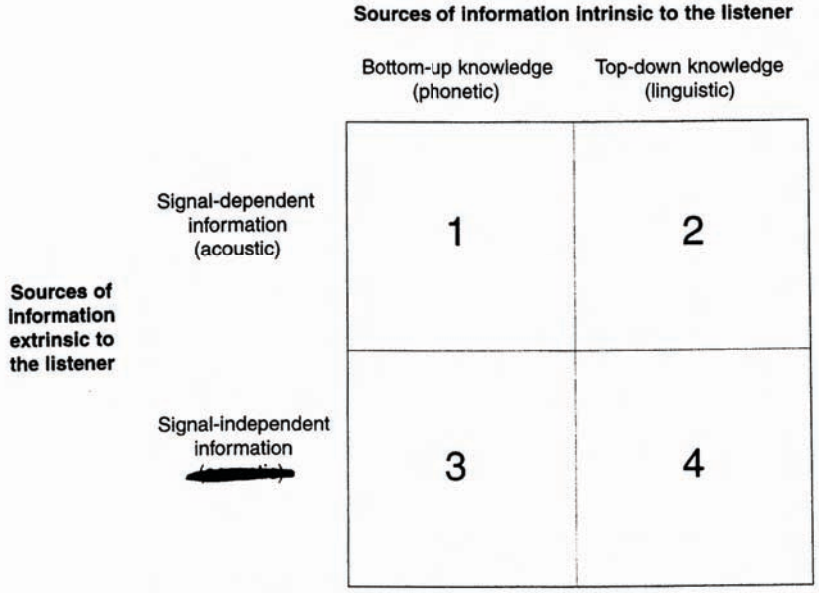

Figure 4. A hybrid model of supplemented communication. (From Hustad, K.C. [1999]. *Effects of context on intelligibility and comprehensibility of severely dysarthric speech* [p. 13]. Unpublished doctoral dissertation, University of Nebraska–Lincoln.)

only the speech signal itself and the listener's bottom-up phonetic knowledge/decoding skills. This situation is unlikely to occur in communicative situations but may occur in the case of decoding nonsense syllables or in syntactically or semantically irregular utterances. The second cell represents availability of only the speech signal from the speaker and top-down linguistic knowledge from the listener. This situation is not likely to occur in a real interaction because listeners are never entirely without their inherent phonetic decoding ability. The third cell represents the availability of only signal-independent information from the speaker with no acoustic phonetic information and only bottom-up phonetic processing from the listener. The fourth cell represents the availability of only signal-independent information from the speaker and only top-down linguistic knowledge from the listener. Clearly, individual cells within this model do not adequately represent typical verbal communication.

When mutually understood, meaningful units that follow standard conventions of the shared language between speaker and listener are employed, listeners rely on both phonetic decoding skills and language knowledge in order to obtain meaning from the speech signal. According to this model, during spoken communication interchanges among adult speakers of the same language, the first cell must always be active. That is, there is always an acoustic speech signal provided by the speaker, and the listener always has access to his or her inherent phonetic decoding or bottom-up knowledge of speech. The listener's ability to employ his or her bottom-up knowledge successfully will vary according to the quality of the speech signal.

Furthermore, in meaningful communicative situations among adult speakers of the same language, the second cell of this model is always be active to some extent. That is, there is always an acoustic speech signal provided by the speaker, and the listener always has access to his or her knowledge of the language to assist in obtaining meaning from the speech signal. However, the extent to which the listener is able to apply his or her top-down linguistic knowledge may vary with the length of the speech material. For example, in narrative discourse, listeners have greater opportunity to apply linguistic knowledge; therefore, greater intelligibility and comprehensibility would be expected compared with sentence-length and word-length material.

The relationship between top-down linguistic knowledge and bottom-up phonetic knowledge in decoding and comprehending spoken language is a topic of considerable debate in the speech perception literature. Separating the contribution of the two sources of knowledge is inferential in nature because spoken language processing is a private event that cannot be directly observed within the mind of the listener.

The third cell of this model represents the contribution of signal-independent information in the form of explicit cues that support the intended message. The cues provided in this condition are developed to enhance the listener's bottom-up phonetic knowledge of the speech signal. When cells 1, 2, and 3 are active, signal-independent cues provide phonetic information in combination with the speech signal. This type of communication strategy is known as *alphabet supplementation,* whereby the listener is given the first letter of each word of the speaker's message (Beukelman & Yorkston, 1977). In this signal-independent cue condition, bottom-up phonetic processing is considered primary and top-down linguistic knowledge secondary.

The fourth cell of this model also represents the contribution of signal-independent information in the form of explicit cues that support the intended message. The cues provided in this condition are developed to enhance the listener's top-down linguistic knowledge of the intended message. When cells 1, 2, and 4 are active, signal-independent cues provide linguistic information in combination with the speech signal. This type of communication strategy is known as *topic supplementation,* whereby the listener is given a topical word or phrase that provides context for the entire message (Dongilli, 1994). In this signal-independent cue condition, top-down linguistic knowledge is considered primary and bottom-up phonetic knowledge secondary.

Finally, when all four cells of this model are considered together, signal-independent cues are provided along with the speech signal to enhance both top-down and bottom-up processing of the message. The relative contribution of each source of information in this condition is assumed to be equal. Research testing the hypotheses posited by this model is underway.

There is clearly a growing body of evidence derived from case studies as well as experimental investigations that support the conclusion that speech supplementation procedures are associated with improvements in speech intelligibility. Additional investigations are needed to further the knowledge base regarding the clinical usefulness of these strategies to bridge research results with clinical practice.

PATTERNS OF SPEECH SUPPLEMENTATION USE

The patterns of the use and acceptance of speech-supplementation procedures by individuals with chronic communication disorders has received very little research attention. Clinical reports indicate that individuals with dysarthria due to a variety of different etiologies have used speech-supplementation strategies. These include Parkinson's disease (Crow & Enderby, 1989; Schumacker & Rosenbek, 1986), brainstem stroke (Beukelman & Yorkston, 1977), traumatic brain injury (TBI) (Beukelman & Yorkston, 1977), motor neuron disease (Crow & Enderby, 1989; Yorkston et al., 1999), and cerebral palsy (Hustad & Beukelman, 1998). However, there is little published information about speakers who are *able* to use these strategies but choose *not* to do so. In the following sections, factors that need to be investigated to enhance understanding of acceptance and rejection of supplemented speech strategies are discussed.

Perceptions of Communication Effectiveness

For speakers who have typical speech ability for many years, the effects of a gradual- or sudden-onset severe speech disorder on communication effectiveness can be difficult to assess. Some individuals appear to overestimate the impact of their speech disorder on communication effectiveness, some underestimate the impact, and others estimate quite accurately.

Sullivan, Brune, and Beukelman (1996) studied the outcomes of group speech intervention for speakers with dysarthria due to Parkinson's disease. Although it was not the primary focus of this investigation, the variability in self-perceptions of communication difficulty reported by these individuals was remarkable. For example, one of the participants demonstrated relatively high intelligibility scores (97.7%) but estimated that more than 80% of all communication situations were difficult for him. His wife's perceptions were quite different in that she estimated that far fewer situations were difficult for him. Following eight group intervention sessions, his speech intelligibility had not changed; however, he had reduced his speaking rate somewhat. At that point, he estimated approximately 60% of all communication situations as difficult, but his wife continued to estimate the impact of his speech disorder to be less severe than he did.

An example from clinical practice provides another illustration of very different self-perceptions of communicative competence. An individual, who also had Parkinson's disease, was largely unaware of his limited communication effectiveness. He spoke at an excessively rapid rate (240 words per minute as compared with an average rate for adult speakers of 190 words per minute). His habitual speech was largely unintelligible. He learned alphabet supplementation and reduced his speaking rate to approximately 40 words per minute. At this rate, his speech was intelligible in all conversational situations. When he spoke over the telephone with his grandchildren, who lived in another state, they would demand that he use alphabet supplementation to control

his speaking rate and improve his intelligibility. On several occasions, he commented that he wondered how they knew that he was not using his alphabet board when he talked over the telephone, because they obviously could not see him. He revealed little awareness of his limited communication effectiveness; therefore, he resisted using alphabet supplementation. His communication partners had to require him to use it.

In a study by Ball and Beukelman (1999), speakers with severe dysarthria due to amyotrophic lateral sclerosis (ALS) and their spouses were asked to rate the speakers' communication effectiveness using a rating scale provided by Yorkston and colleagues (1999). The results revealed that speakers and their spouses rated their communication effectiveness very similarly. Additional information about the acceptance and rejection of AAC technology by individuals with ALS can be found in Chapter 7.

Hustad and Beukelman (1998) reported a case illustration demonstrating diverse perceptions of situational communication effectiveness. In this example, a variety of adult communication partners were asked to estimate the speech intelligibility of a 6-year-old child with severe speech intelligibility challenges. Results showed that the parents and close family members estimated that the child was 85% intelligible at home. School personnel estimated the child's intelligibility at school to be between 20% and 30%. Objective measures of intelligibility, obtained from the same listeners who provided the previous estimates, revealed intelligibility scores ranging between 15% and 35% for this child. When the intelligibility of speakers is rated to be very different across situations and partners, it is not uncommon that conflicts about the need for AAC or supplemented speech strategies occur. There has been little similar research for adults with acquired communication disorders.

Differing perceptions of communication effectiveness across situations may also contribute to attitudes toward AAC use by individuals with speech disorders. Hustad and Beukelman (1998) described a 26-year-old man with cerebral palsy. Results of the Sentence Intelligibility Test (Yorkston, Beukelman, & Tice, 1996) revealed that this man's intelligibility was 21%. However, through the years, he had resisted using an AAC system in any situation. When asked to rate his communication effectiveness, his mean rating was 5.2 on a 7-point scale, indicating that he felt quite effective across communicative situations. The mean rating by his mother was 5.0. However, the mean rating by young adults who did not know him well but had encountered him in casual interaction was 2.2. The reasons that this young man was unwilling to use an AAC system may be suggested by these discrepant ratings. Because his parents evaluated his communication effectiveness so highly and because they were such important people in his life, perhaps he accepted their evaluation rather than that of peers and strangers. He apparently was so convinced of his communication effectiveness that he rejected AAC in any social situation, even though it seemed quite obvious that peers and strangers had difficulty understanding him. Because he had rejected the use of an AAC system, he did not have the strategies available to shift from his speaking mode to supplemented speech or an augmented communication mode in times of communication difficulty or breakdown.

Metacognitive Ability of the Speaker to Switch Modes

Given that communication effectiveness varies across social situations and listeners, it is important that individuals who use natural speech, speech-supplementation, and AAC strategies learn to switch communication modes depending on the situation and the listener. In the previous example, the young man did not have an AAC system available to switch to when the need arose.

The metacognitive ability to assess communication success or failure in a communication interaction is necessary for successful use of a multimodal communication system. In some individuals, metacognitive skills can be improved with coaching and practice. Hustad and Beukelman (1998) provided an illustration of the successful use of metacognitive skills for mode switching according to the communicative situation and partners. When interacting with familiar listeners, this speaker used natural speech as her primary mode of communication. If, after two repetitions of a message, listeners were unable to understand her, she used alphabet supplementation to support her natural speech. When alphabet supplementation failed, she used a voice output communication device as an alternative to her natural speech. When interacting with unfamiliar listeners, this woman's primary mode of communication was through her voice output communication device. Interestingly, this woman's average rate of successful communication was approximately 3.5 words per minute when using her voice output communication device to generate unique messages. However, when she used her natural speech with alphabet supplementation, her average rate of successful communication was between 12 and 15 words per minute, depending on the context.

The information reported in this section consists of primarily clinical reports and case illustrations. Future research is needed to identify the metacognitive skills required to determine whether to use residual speech, supplemented speech, or AAC methods. Development of protocols as well as efficacy research regarding how to teach these skills is necessary. Obviously, an enormous amount of investigation is needed in this area.

Functional Change in Performance

Chapter 3 discusses strategies to develop empirically supported interventions for individuals with disabilities. In that chapter, the chronic disabilities model and the disablement model are reviewed, both of which view chronic disabilities at social and functional levels as well as anatomic and physiologic levels. For interventionists who serve people with chronic disabilities, a central question is whether a change in performance in response to an intervention results in a functional change in the important social situations of the individual's lives. At this point, the motor speech disorders field has limited tools with which to address this question. To date, researchers and clinicians have relied extensively on speech intelligibility measures. A few measures of communication effectiveness, communication effort, and communication difficulty have been proposed; however, these measures are still in their infancy. Future research needs to address multiple issues related to the impact of intervention on communication effectiveness in social situations.

CLOSING COMMENTS

For adults with severe, acquired communication disorders, the integration of speech and AAC is an important intervention issue. As is clear from the staging discussion in Chapter 7, speakers with either degenerative or recovering conditions often make use of AAC, supplemented speech, natural speech, or a combination of these only at some stage in the course of their illness or condition. There is preliminary evidence to suggest the beneficial impact of supplemented speech strategies. However, the level of empirical support for these interventions is still very low. Chapters 3, 8, and 10 review several models (mutuality, chronic disability, and disablement) that have guided and will guide the inquiries of intervention researchers. At the beginning of the 21st century, both the speech disorders and AAC fields view AAC and natural speech as aspects of a multimodal communication system rather than as dichotomous intervention choices. It appears that the climate is conducive for extensive inquiry into the relations among natural speech, supplemented speech, and AAC for adults with acquired communication disorders.

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5

Acceptance of AAC by Adults with Acquired Disorders

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Adults with acquired communication disorders are a unique clinical population. Many of them experience life-threatening health issues as a result of sudden or gradual disease processes. These individuals face a number of challenges. They may be unable to return to their jobs, which often results in financial stress. Roles and responsibilities within the family shift. Many of the activities of daily living, such as dressing, eating, walking, or driving, become difficult or impossible. In addition to these challenges, severe expressive communication disorders, such as aphasia, motor speech disorders, and dementia, may result in dramatic lifestyle changes. Often, adults with acquired communication disorders can no longer communicate in the manner to which they are accustomed. As a result, they may avoid participating in many of their former daily activities. They may remember the nature of their relationships with others and may now be aware that people respond to them differently. For people who once had typical speech ability, the loss of spoken communication signifies an enormous life change. (See Chapter 1 for a detailed discussion of communication role changes.)

In order to address the severe communication disorders of these adults, augmentative and alternative communication (AAC) strategies and systems have been developed. These tools have been shown to enhance communication effectiveness, communication repertoire, and