The Influences of Alphabet Supplementation, Iconic Gestures, and Predictive Messages on Intelligibility of a Speaker With Cerebral Palsy

Katherine C. Hustad, Ph.D.

Department of Communication Sciences and Disorders
Pennsylvania State University
University Park, Pennsylvania

Jane Mertz Garcia, Ph.D.

Department of Communication Sciences and Disorders
Kansas State University
Manhattan, Kansas

This study compared the effects of alphabet supplementation and iconic hand gestures for a speaker with spastic dysarthria as the result of cerebral palsy. Stimulus sentences produced by the speaker contained low and high predictive content. A total of 24 inexperienced listeners orthographically transcribed sentences produced using habitual speech, alphabet supplementation, and iconic hand gestures following audio-video presentation. Results showed that both strategies, alphabet supplementation and iconic hand gestures, significantly improved intelligibility of severely dysarthric speech relative to habitual speech, but that the two strategies did not differ from one another. In addition, sentences that were high predictive resulted in better intelligibility scores than sentences that were low predictive. The magnitude of improvement associated with both alphabet supplementation and iconic hand gestures suggests that both are viable intervention strategies for the present speaker.

Cerebral palsy (CP) is a nonprogressive, developmental disability characterized by motor control deficits that often affect the entire body. Although there have not been recent investigations of the prevalence of dysarthria in individuals with CP, historical estimates suggest that between 31% (Wolfe, 1950) and 88% (Achilles, 1955) of those with CP have dysarthria. Communication interventions for individuals with CP have traditionally focused on improving underlying speech subsystem problems (McDonald, 1987; Yorkston, Beukelman, Strand, & Bell, 1999) or on use of augmentative and alternative communication systems as an alternative to speech (Beukelman & Mirenda, 1998; Mecham, 1996). Recent research suggests that compensatory communication interventions such as alphabet supplementation and iconic hand gestures, used in conjunction with speech, can have a dramatic effect on intelligibility of individuals with different types of dysarthria (Beukelman & Yorkston, 1977; Garcia & Cannito, 1996; Garcia & Dagenais, 1998; Hustad & Beukelman, 2001). Although both iconic hand gestures and alphabet supplementation provide listeners with additional

Journal of Medical Speech-Language Pathology
Volume 10, Number 4, pp. 279–285

contextual information that can enhance intelligibility, the nature of the information provided by each differs.

Alphabet supplementation is a strategy in which speakers use an alphabet board to indicate the first letter of each word while simultaneously speaking. Only three published studies have examined the effects of this strategy on intelligibility of sentences. However, these studies show that alphabet supplementation can improve sentence intelligibility between 15% and 44% (Beukelman & Yorkston, 1977; Crow & Enderby, 1989; Hustad & Beukelman, 2001). Although existing studies have employed different methods and consequently addressed somewhat different questions, two general conclusions can be inferred. First, alphabet supplementation seems to reduce rate of speech, which in turn may provide listeners with clearer word boundaries and increased processing time, ultimately contributing to improvements in intelligibility. Second, word-initial grapho-phonemic information associated with implementation of alphabet supplementation may serve to reduce lexical ambiguity so that only those word candidates beginning with the target letter are viable options, thus increasing listeners' decoding accuracy (Hustad & Beukelman, 2001).

Use of hand gestures while speaking adds some degree of nonverbal content to the spoken signal. Iconic gestures, in particular, are closely related to the semantic content of target sentences (McNeill, 1992). Because they contribute information that is additional to speech, the redundancy or added information provided by iconic hand gestures can help listeners decode the spoken message (Bull, 1983; Rogers, 1978). Because they visually illustrate some aspect of the corresponding spoken message, iconic hand gestures are of special interest as an intervention strategy for speakers with dysarthria. Existing research examining speakers with acquired dysarthrias suggests that speaker-implementation of iconic gestures can improve intelligibility between 20 and 38% relative to habitual speech (Garcia & Dagenais, 1998). The effect of iconic gestures on the speech of individuals with chronic dysarthria secondary to CP has not been examined, and may differ from speakers with acquired dysarthria due to the different associated neuromotor problems.

While both approaches (alphabet supplementation and iconic gestures) provide listeners with an additional source of contextual information, the effectiveness of each strategy may be altered by the content of the speaker's message such as its sentence structure (Carter, Yorkston, Strand, & Hammen, 1996) or semantic content (Garcia & Cannito, 1996; Garcia & Dagenais, 1998; Garcia & Hayden, 1999). Research examining the effects of semantic predictiveness on the intelligibility of speech produced in conjunction with iconic gestures clearly demonstrates its importance, with iconic gestures having a greater impact on messages that are high predictive relative to those that are low predictive in the audio-visual presentation mode. Of note, results from these studies are limited to speakers with dysarthria from acquired causes. Predictive message content has not been a consideration in previous studies of speakers with CP or examined in conjunction with alphabet supplementation.

In summary, there is little published information about the impact of contextual influences on intelligibility for speakers with dysarthria resulting from CP. For example, the relative effectiveness of alphabet supplementation compared with iconic gestures and habitual speech for individuals with CP is unknown. Understanding the relative efficacy of these strategies could lead to valuable low-cost clinical interventions for individuals with CP. The purpose of the present study, which is part of a larger project, was to compare the effects on intelligibility of speech produced using alphabet supplementation, speech produced using iconic hand gestures, and speech produced in a habitual fashion for one speaker with spastic dysarthria secondary to CP. A secondary purpose was to examine the effects of semantic predictiveness on the intelligibility of speech produced using alphabet supplementation, speech produced using iconic hand gestures, and speech produced in a habitual fashion for this same speaker.

METHOD

Subjects

A 42-year-old woman with moderate-severe spastic dysarthria served as the speaker. She had a medical diagnosis of cerebral palsy (spastic diplegia) and both gross and fine motor movements were restricted in range and precision. The speaker used a wheelchair for mobility, but was able to use her upper extremities functionally for most activities of daily living, requiring minor assistance from a personal care attendant for some fine motor tasks. Perceptually, her speech was characterized by a slow rate, short phrases, impaired articulatory movements, and harsh vocal quality. She used speech as

her primary mode of communication and did not use any other compensatory strategies when partners were unable to understand her. The speaker met the following criteria: (a) intelligibility between 5 and 50% as measured by the *Sentence Intelligibility Test* (Yorkston, Beukelman, & Tice, 1996); (b) native speaker of American English; (c) able to produce connected speech consisting of at least 8 consecutive words; (d) motor skills to point to alphabet cues on a communication board; and (e) functional motor skills to produce iconic gestures using her dominant hand.

A total of 24 nondisabled individuals served as listeners. The listeners were females and ranged in age from 18 to 24 years of age. The mean age of listeners was 20.6 years (SD = 1.4). Listeners passed a pure tone hearing screening bilaterally at 25 dBHL for 1000, 2000, and 4000 Hz; were native speakers of American English; and had no special experience listening to dysarthric speech.

Materials

The 24 test sentences produced by the speaker with dysarthria were 6 to 8 word imperatives. They were comprised of one and two syllable words, and designed to include two scripted iconic gestures (see Garcia & Dagenais, 1998, for additional information about the development of test sentences and iconic gestures). In summary, verbal predictiveness represented the amount of predictive information within each sentence determined through a cloze testing procedure (i.e., subjects predicted missing target words from the surrounding sentence content). Nonverbal predictiveness represented the information value of the gestured message (i.e., ability to interpret sentence content from its gestural cues alone). The test sentences were equally divided between sentences that were low and high nonverbal (gestural) and verbal (spoken) predictive. Nonverbal and verbal content of each sentence was significantly correlated, r (24) = .78, $p < .01$. Sample low and high predictive sentences and their gestural descriptions are provided in Table 1.

Procedures

Recording the Speaker

Using digital video and digital audiotape, the speaker was recorded in a quiet environment. Video recordings focused on the speaker's upper body so that her face, hand movements, and communication board were clearly visible. Test sentences were produced by the speaker a total of four times, once prior to strategy instruction using habitual speech, once using alphabet cues, and twice using scripted iconic gestures. For all test sentences, an orthographic representation was provided on a laptop computer, which was positioned directly in front of the speaker yet out of the camera's view. In addition, a verbal model was presented for each sentence. The speaker was instructed in the use of each strategy by the first author (KH).

For the iconic hand gestures condition, the speaker viewed a videotape of a non-neurologically impaired individual producing each test sentence and its associated gestures two times on a portable palm-top-sized digital video cassette player (Sony DVG900). Following video presentation of each sentence, the speaker was asked to produce the sentence and associated gestures two times. The speaker was allowed to view the videotape of each sentence until she felt comfortable with the gesture and her ability to produce it. The second of the speaker's productions for each test sentence was used in this study.

For the alphabet supplementation condition, the strategy was described to the speaker and then modeled for her. The speaker was provided with an 8.5 × 14 inch alphabet board, positioned directly in front of her and was asked to practice using alphabet supplementation on a series of 5 practice sentences until she was able to use alphabet supplementation comfortably and accurately. For all test sentences, the speaker was required to produce

TABLE 1. Sample test sentences and gesture descriptions.

Low-predictive test sentence:
Slice the bread and butter it.
(downward movement, then back and forth movement with closed hand)
High-predictive test sentence:
Shut the door and lock it.
(palm facing forward and moving away from body, turning motion with hand)

each sentence with 100% accuracy for letter identification and gesture production.

Constructing Stimulus Tapes

Video and audio recordings from the speaker were edited using Adobe Premiere 6.0 (computer software) for Macintosh and SoundForge 4.1 (computer software) for Windows. All audio samples were amplitude normalized to 69 dB and matched with video following conventions detailed in Hustad and Cahill (in press). Files for each stimulus sentence and each condition (habitual speech, alphabet supplementation, and iconic hand gestures) were sequenced so that each task was preceded by spoken instructions, each sentence was preceded by a number, and each sentence was followed by a 14-second pause to write down what the speaker said. This sequence was then exported from the computer to digital videotape (via Firewire) and dubbed to VHS tape for playback to listeners.

For the alphabet cues condition, individual graphemes, representing the first letter of each word and corresponding to the target on the alphabet board to which the speaker was pointing, were shown on the video screen. Graphemes were displayed for the duration of the target word as determined by visual inspection of the waveform. This was necessary so that listeners could see the letter to which the speaker was pointing. For the iconic hand gestures condition and the habitual speech condition, no additional information beyond the video images of the speaker was provided.

Randomization and Counterbalancing

Within each cue condition, half of the target sentences were high predictive and half were low predictive. High and low predictive sentences were randomly assigned to each task and were randomly ordered within each task. Two separate sets of stimulus tapes were constructed with different sentences assigned to each cue condition to guard against an order effect for the stimulus sentences. Half of the listeners viewed each set of stimulus tapes. In addition, the order of presentation of each of the three tasks was counterbalanced to prevent a learning effect.

Stimulus Presentation to Listeners

Listeners were tested individually or in a group of two. Videotapes were shown using a JVC S7200 S-VHS player and 27-inch high-resolution Panasonic monitor. The audio signals from the tape were presented at a consistent loudness level approximating conversational speech (average level of 65 dB SPL) in a quiet listening environment. All listeners viewed a familiarization tape that consisted of three practice sentences from the *SIT* (Yorkston et al., 1996). Listeners completed three experimental tasks as follows: (a) 8 sentences produced with iconic gestures (4 low and 4 high predictive), (b) 8 sentences produced with alphabet cues (4 low and 4 high predictive), and (c) a control condition in which 8 sentences (4 low and 4 high predictive), were produced using habitual speech. The sentences presented in each condition were unique, so that listeners heard a total of 24 different sentences. All directions were videotaped and played at the beginning of each experimental condition. Presentation order of cue conditions was counterbalanced to prevent the possibility of a learning effect.

Scoring

Listeners transcribed verbatim what they thought the speaker said in each condition. Transcriptions were scored according to whether or not each word phonemically matched the target word produced by the speaker. Misspellings and homonyms were accepted as correct. The number of correctly transcribed words was summed for each listener within each listening condition and converted to a percent intelligibility score.

RESULTS

The mean intelligibility scores and their standard deviations for each listening condition are presented graphically in Figure 1. Intelligibility data were analyzed using a 2×3 within subjects analysis of variance. The first within subjects variable was cue condition and its categories were habitual speech, alphabet supplementation, and iconic hand gestures. The second within subjects variable was predictiveness, and its categories were high predictive, and low predictive sentence stimuli.

Results showed significant main effects of cue condition ($F = 55.841$; $p < .001$). Follow-up contrasts revealed that alphabet cues resulted in significantly higher intelligibility scores than no cues ($t = 9.659$; $p < .001$), gestures resulted in significantly higher intelligibility scores than no cues ($t = 8.704$; $p < .001$), and alphabet cues and gestures did not differ from each other with regard to intelligibility.

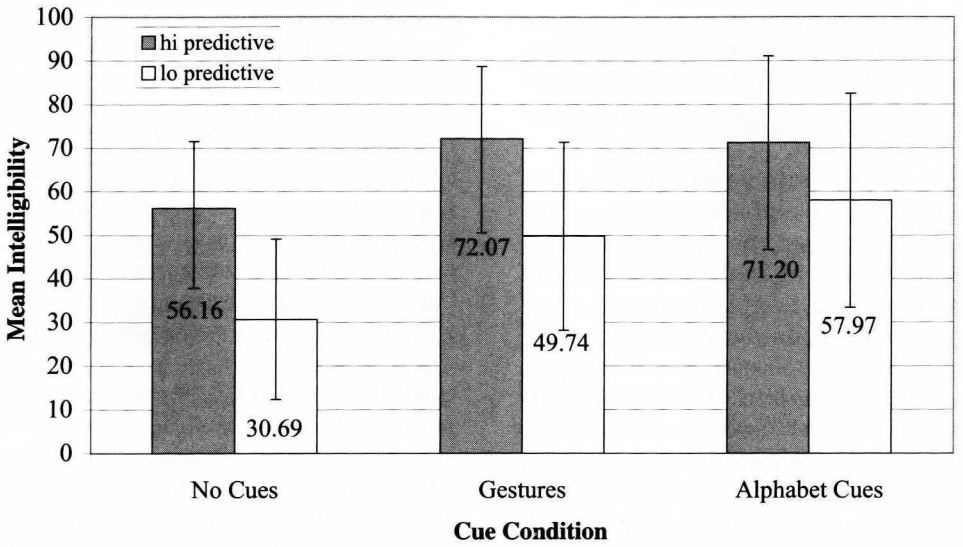

Figure 1. Mean intelligibility scores by cue condition and predictiveness (± *SD*).

The main effect of predictiveness was also significant ($F = 189.34$; $p < .001$) with sentences that were high predictive resulting in significantly higher intelligibility scores than sentences that were low predictive across all cue conditions. In addition, the interaction between cue conditions and predictiveness was not significant ($F = 1.707$; $p = .203$), indicating that predictiveness enhanced intelligibility to the same extent, regardless of the cue condition.

DISCUSSION

The results of this preliminary study showed that both alphabet supplementation and iconic hand gestures significantly enhanced the intelligibility of moderate-severely dysarthric speech of one individual with CP. Furthermore, the effects of both strategies were similar with respect to the magnitude of intelligibility improvement observed. Results for alphabet supplementation and iconic hand gestures relative to habitual speech were both consistent with previous research. When listeners were provided with nonverbal information via gestures, mean intelligibility scores improved by an average of 28% (*SD* = 15.5%) relative to habitual speech (no cues), which is similar to previous studies examining speakers with moderate to profound intelligibility impairments resulting from acquired dysarthrias (Garcia & Cannito, 1996; Garcia & Dagenais, 1998). Likewise, when listeners were provided with word-initial information via alphabet supplementation, intelligibility scores improved by an average of 32% (*SD* = 16.2%), which is consistent with previous research examining alphabet supplementation (Beukelman & Yorkston, 1977; Crow & Enderby, 1989; Hustad & Beukelman, 2001).

The finding that alphabet supplementation and iconic gestures both resulted in similar intelligibility gains suggests that contextual information, of any type, provides important cues to listeners that impact intelligibility. That is, nonverbal paralinguistic context via gestures and explicit linguistic cues via word initial graphemes can have a similar effect on intelligibility, even though the nature of the information provided differed substantially. However, there were commonalities between the two types of cues that may be responsible for their similar affect on intelligibility. Specifically, both types of cues were provided simultaneously with the speech signal so that redundant information was available to listeners in both temporal and contextual domains, perhaps having an additive effect, thus increasing intelligibility. The impact of both strategies on intelligibility is particularly compelling when considered in light of the speaker's significant motor impairment affecting her entire body and making the implementation of both strategies somewhat effortful. The value of both intervention strategies is further highlighted when the intelligibility gains are examined relative to habitual intelligibility. Not only did intelligibility improve by a magnitude of 30% with both strate-

gies, but also overall intelligibility scores increased from approximately 46% to nearly 80%, suggesting that both strategies had a marked effect on the functionality of the speaker's communicative performance in this experiment.

It is important to note that several differences between the two strategies, alphabet supplementation and iconic hand gestures, may result in differential intelligibility gains in real communication situations. Specifically, the linguistic nature of alphabet supplementation makes it a generative strategy that can be employed with any utterance, regardless of semantic content. In addition, alphabet supplementation can be used to resolve communication breakdown more readily than gestures can because cues are provided for each word of the spoken utterance. Thus, the speaker can backtrack to a specific word with which the listener had difficulty and repeat the cue for that word, or the speaker can spell an entire word using the alphabet board. Iconic gestures, on the other hand, are paralinguistic cues that provide information that is more gestalt in nature. As a result, some messages may not have corresponding gestures. A speaker may choose gestures that a listener may have difficulty interpreting, potentially serving as a distractor in the communication process. Likewise, the use of iconic gestures to resolve communication breakdown would be seemingly more cumbersome because gestures are not provided for each word of the utterance, but for the utterance as a whole. However, iconic gestures are an unaided strategy that can be implemented without any external means. Therefore, gestures can be used in any situation, making them quite flexible.

Finally, the results from this study showed that predictive messages were a powerful influence regardless of cue condition. When collapsed across cue conditions, there was an intelligibility increase of approximately 19% (SD = 6.71%) for messages that were high predictive relative to low predictive. The results from this study are comparable to other works of Garcia and colleagues (Garcia & Cannito, 1996; Garcia & Dagenais, 1998), indicating the importance of predictive message content to listener understanding. This is the first documented report showing that listeners also benefited from predictive sentence information in conjunction with alphabet supplementation.

The results of this study highlight the value of developing treatment programs that emphasize the importance of contextual influences to understanding dysarthric speech. The large improvements associated with the different listening conditions indicate that listener understanding can be greatly enhanced by certain types of contextual information. However, actual implementation of each strategy in real communication situations may yield different outcomes from those of the present research. In particular, the very nature of the research paradigm may have elevated intelligibility gains for both strategies in a way that is different from natural communicative interactions. For example, this study maximized the benefit of alphabet cues by superimposing the first letter of each word on the viewing monitor. In natural interactions, communication partners are required to carefully listen while watching the pointing movements of the speaker to each letter. Similarly, iconic hand gestures in this study were carefully scripted to accurately represent the semantic content of messages. In spontaneous implementation of this strategy, the match between the gesture and the semantic content of the message would not necessarily be as consistent as it was in the present study.

The present study represents a first step at examining the effects of two low-cost interventions that do not require specialized equipment or training to implement and therefore should be readily accessible to many individuals with chronic dysarthria such as those with CP. Additional research is necessary to expand the generalizability of these findings, to examine the learning requirements and the cognitive load imposed by both strategies in real communication situations, and to examine the efficacy of both strategies in ecologically valid communicative contexts. Importantly, speaker and listener acceptance of each strategy should be examined in future research.

Address correspondence to Katherine Hustad, Penn State University, 110 Moore Building, University Park, PA 16803 USA
e-mail: kch2@psu.edu

REFERENCES

Achilles, R. (1955). Communication anomalies of individuals with cerebral palsy: I. Analysis of communication processes in 151 cases of cerebral palsy. *Cerebral Palsy Review, 16,* 15–24.

Adobe Premiere 6.0 [computer software] (2001). San Jose, CA: Adobe Systems Incorporated.

Beukelman, D. R., & Mirenda, P. (1998). *Augmentative and alternative communication* (2nd ed.). Baltimore: Paul H. Brookes.

Beukelman, D., & Yorkston, K. (1977). A communication system for the severely dysarthric speaker with an in

tact language system. *Journal of Speech and Hearing Disorders, 42,* 265–270.

Bull, P. (1983). *Body movement and interpersonal communication.* New York: John Wiley & Sons.

Carter, C. R., Yorkston, K. M., Strand, E. A., & Hammen, V. (1996). The effects of semantic and syntactic content on the actual and estimated sentence intelligibility of dysarthric speakers. In D. Robin, K. M. Yorkston, & D. R. Beukelman (Eds.) *Disorders of Motor Speech: Assessment, Treatment, and Clinical Characterization* (pp. 67–87). Baltimore: Paul H. Brookes.

Crow, E., & Enderby, P. (1989). The effects of an alphabet chart on the speaking rate and intelligibility of speakers with dysarthria. In K. M. Yorkston & D. R. Beukelman (Eds.), *Recent Advances in Clinical Dysarthria* (pp. 99–108). Boston: College Hill Press.

Garcia, J. M., & Cannito, M. (1996). Influence of verbal and nonverbal contexts on the sentence intelligibility of a speaker with dysarthria. *Journal of Speech and Hearing Research, 39,* 750–760.

Garcia, J. M., & Dagenais, P. A. (1998). Dysarthric sentence intelligibility: Contribution of iconic gestures and message predictiveness. *Journal of Speech, Language, and Hearing Research, 41,* 1282–1293.

Garcia, J. M., & Hayden, M. (1999). Young and older listener understanding of a person with severe dysarthria. *Journal of Medical Speech-Language Pathology, 7,* 109–112.

Hustad, K. C., & Beukelman, D. R. (2001). Effects of linguistic cues and stimulus cohesion on intelligibility of severely dysarthric speech. *Journal of Speech, Language, and Hearing Research, 44,* 497–510.

Hustad, K. C., & Cahill, M. A. (in press). Effects of visual information and repeated sequential listening experience on intelligibility of dysarthric speech. *Manuscript submitted for publication.*

McDonald, E. T. (1987). Speech production problems. In E. T. McDonald (Ed.), *Treating Cerebral Palsy: For Clinicians By Clinicians* (pp. 171–190). Austin, TX: Pro-Ed.

McNeill, D. (1992). *Hand and mind: What gestures reveal about thought.* Chicago: The University of Chicago Press.

Mecham, M. J. (1996). *Cerebral palsy.* Austin: Pro-Ed.

Rogers, W. T. (1978). The contribution of kinesic illustrators toward the comprehension of verbal behavior within utterances. *Human Communication Research, 5,* 54–62.

Sound Forge 4.5 [computer software], (1998). Madison, WI: Sonic Foundry.

Wolfe, W. (1950). A comprehensive evaluation of fifty cases of cerebral palsy. *Journal of Speech and Hearing Disorders, 15,* 234–251.

Yorkston, K. M., Beukelman, D. R., Strand, E. A., & Bell, K. R. (1999). *Management of motor speech disorders in children and adults.* (2nd ed.). Austin, TX: Pro Ed.

Yorkston, K., Beukelman, D. R., & Tice, R. (1996). *Sentence intelligibility test for windows.* Lincoln: Communication Disorders Software. Distributed by Tice Technology Services, Lincoln, NE.