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Use of Listening Strategies for the Speech of Individuals with Dysarthria and Cerebral Palsy

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This study examined listeners' endorsement of cognitive, linguistic, segmental, and suprasegmental strategies employed when listening to speakers with dysarthria. The study also examined whether strategy endorsement differed between listeners who earned the highest and lowest intelligibility scores. Speakers were eight individuals with dysarthria and cerebral palsy. Listeners were 80 individuals who transcribed speech stimuli and rated their use of each of 24 listening strategies on a 4-point scale. Results showed that cognitive and linguistic strategies were most highly endorsed. Use of listening strategies did not differ between listeners with the highest and lowest intelligibility scores. Results suggest that there may be a core of strategies common to listeners of speakers with dysarthria that may be supplemented by additional strategies, based on characteristics of the speaker and speech signal.

Keywords: Intelligibility; Intervention; Dysarthria, Cerebral Palsy; Speech perception

INTRODUCTION

Many individuals who require AAC have at least some residual speaking capability, and conversely, many individuals with speech impairments such as dysarthria could benefit from AAC (Beukelman, Garrett, & Yorkston, 2007; Beukelman & Mirenda, 2005; Hustad & Beukelman, 2000). Speech and AAC can complement one another in a variety of ways. For example, some individuals may use speech as a primary mode of communication, with AAC employed primarily as a back up for communication breakdown situations. Others may use AAC for enhancing intelligibility (as with speech supplementation strategies) (Hanson, Yorkston, & Beukelman, 2004). Specific partners and contexts may play an important role in determining the ways in which speech and AAC are integrated at any given time. Regardless of the individual's speaking capability, natural speech is often a key part of a multi-modal communication package.

Speech intelligibility is an important variable that can impact the effectiveness of natural speech and the efficiency and ease of communication. Although speech intelligibility is often considered an attribute of the speaker, the listener's ability to make sense of the distorted speech signal plays a critically important role. A growing body of literature is beginning to focus on listener-related variables that contribute to speech intelligibility (see Hustad, 2006, 2007a; Klasner & Yorkston, 2005; Liss, Spitzer, Caviness, & Adler, 2002) and the interaction between speaker and listener variables (see Liss, Spitzer, Caviness, Adler, & Edwards, 1998; 2000). Among other things, this research leads to the possibility that one way to enhance speech intelligibility may be to train listeners of speakers with chronic dysarthria so that they are better able to make sense of the speech signal. A precursor to this type of listener intervention is an understanding of barriers and strategies that listeners experience when presented with dysarthric speech.

Strategies and Barriers to Listening to Dysarthric Speech

Klasner and Yorkston (2005) examined barriers and strategies of everyday listeners when presented with dysarthria secondary to amyotrophic

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lateral sclerosis (ALS) and Huntington's disease (HD). From this work, they developed a barrier scale and a strategy scale using focus groups of individuals who listened to and transcribed dysarthric speech produced by individuals with ALS and HD. Because listening strategies were of primary interest for the present study, only the development and use of the strategy scale will be discussed here. Interested readers are referred to Klasner and Yorkston for additional information regarding development and use of the barrier scale.

Using a qualitative methodology to analyze focus group results, Klasner and Yorkston (2005) found that four categories of listening strategies emerged from focus group discussions: segmental, suprasegmental, linguistic, and cognitive. Klasner (2003) defined each of these as follows: Segmental strategies included those that related to phonemes or phonetic structure; suprasegmental strategies were those that related to rate, rhythm, or prosody; linguistic strategies were those that related to meaning or grammar; and cognitive strategies were those that related to cognitive processes such as attention and effort. Within each strategy category, six constituent items were identified, for a total of 24 strategies comprising the scale. The items in Klasner and Yorkston's strategy scale are presented in the Appendix.

To validate their strategy scale, Klasner and Yorkston (2005) conducted an experiment in which they asked listeners to rate their use of the various strategies that comprised the instrument. In this study, listeners heard speech samples from individuals with dysarthria (intelligibility between 60% and 90%) twice, orthographically transcribed what they heard, and compared their transcription to an answer key. The listeners then responded to each of the 24 barrier statements (six statements in each of the four categories) and each of the analogous 24 strategy statements using a four-point scale: 4 (strongly agree), 3 (agree), 2 (disagree), 1 (strongly disagree).

Results showed that, among the 10 strategies with the highest endorsement[1] rankings, there were only four strategies that were common to listeners of speakers with ALS and HD, three of which were from the cognitive category and one of which was from the segmental category. For speakers with dysarthria secondary to ALS, three additional segmental strategies were endorsed along with two cognitive strategies, and one suprasegmental strategy. For speakers with dysarthria secondary to HD, three additional suprasegmental strategies were endorsed, along with one segmental and two linguistic strategies. From these findings, Klasner and Yorkston (2005) suggested that there might be certain cognitive strategies that are common for listeners of speakers with dysarthria of any origin. They further suggested that listeners of speakers with dysarthria secondary to ALS might depend primarily on segmental strategies, whereas listeners of speakers with dysarthria secondary to HD might depend primarily on suprasegmental strategies.

In the present study, we sought to examine strategy use among listeners of speakers with cerebral palsy (CP) to determine whether they used strategies consistent with those identified in Klasner and Yorkston's (2005) study. We also expanded on Klasner and Yorkston's work by setting operationally defined criteria for highly endorsed and highly "dis-endorsed" strategies. Thus, the particular focus of the present study was to examine which categories and constituent strategies were highly endorsed and highly dis-endorsed by listeners of speakers with CP.

Variability in Listener Performance

Intelligibility studies involving speakers with dysarthria often reveal that there is marked variability among listeners, even those who hear the same speaker producing the same speech stimuli (see Beukelman, Fager, Ullman, Hanson, & Logemann, 2002; Garcia & Dagenais, 1998; Hustad, Jones, & Daily, 2003; Liss et al., 2002). Although this variability is well documented in the dysarthria literature, studies have not explicitly quantified sources of variability among listeners. However, one set of candidate variables is the listening strategies identified by Klasner and Yorkston (2005). An understanding of whether there are differences among listeners in the use of different strategies may be the first step in developing interventions that aim to improve intelligibility by teaching listening strategies. One method for doing this is to study differences between so-called "strong" and "weak" listeners (as indicated by intelligibility scores). If differences in strategy use exist, it may be possible to teach weaker listeners to use the strategies employed by the stronger listeners in order to improve speech intelligibility.

The present study examined the types of strategies that listeners used (as indicated by the Klasner & Yorkston, 2005, scale) when presented with the speech of individuals with dysarthria secondary to CP. We addressed two specific questions: Which categories of strategies and specific constituent strategies are most highly endorsed by listeners of speakers with dysarthria secondary to CP? and Is there a difference between strategies endorsed by listeners with the lowest (weak) and listeners with the highest (strong) intelligibility scores?

METHOD

Participants: Speakers and Listeners

Eight speakers with dysarthria secondary to CP contributed speech samples for this study. Speakers ranged in age from 18–76 years. Inclusion criteria required that speakers (a) use American English as their first and primary language, (b) have normal hearing per self-report, (c) be able to repeat sentences of up to 15 words in length following a verbal model, and (d) produce each target word in the stimulus sentence in the appropriate sequence. All speakers had intelligibility scores between 75% and 95%, as determined by Sentence Intelligibility Test (SIT) (Yorkston, Beukelman, & Tice, 1996) data obtained for the intelligibility portion of this study, and all had mild-moderate dysarthria. Demographic characteristics of speakers are provided in Table 1.

Eighty listeners with normal hearing participated in the study. They were university students and members of the local community. The mean age of listeners was 21.07 years ($SD = 2.32$). Inclusion criteria required that listeners (a) pass a pure-tone hearing screening at 20 dB HL for 1 kHz, 2 kHz, and 4 kHz bilaterally; (b) be between 18 and 45 years of age; (c) have no more than incidental experience listening to or communicating with persons having communication disorders; (d) be native speakers of American English, (e) report normal or near-normal vision with correction; and (f) have no identified language, learning, or cognitive disabilities per self-report.

Speech Samples: Materials and Procedures

Speakers with dysarthria produced 70 different sentences from the Sentence Intelligibility Test (SIT). Sentences varied in length between 5 and 15 words. Each speaker produced the same corpus of sentences.

Audio recordings of the speakers were made in a sound-attenuating booth using professional quality digital recording equipment (Marantz PMD560 Solid State Recorder)[2], including a head-mounted low-profile microphone (Countryman E6)[3]. Speakers were required to produce each target sentence following a verbal model. An orthographic representation of each target sentence was also shown on a laptop computer located directly in front of the speaker. During recording, speakers were required to meet one criterion: produce all target words in each sentence in the appropriate sequence. This criterion was monitored online by the experimenter.

Audio recordings (16-bit; 44,100 Hz) were copied directly onto a computer from a flash-card reader. Digital audio recordings were separated into individual files using Sound Forge 6.0 [computer software] (2003). In addition, extraneous noises were removed from the recordings. Files were peak-amplitude normalized in order to assure that the maximum loudness levels of the recorded speech stimuli were consistent across all of the speakers and sentences.

TABLE 1 Demographic Information for Speakers with Dysarthria and CP.

Speaker	Age	Sex	Dysarthria type	Intelligibility[a]
1	46	M	Spastic	78
2	18	F	Spastic	79
3	57	M	Spastic	81
4	50	F	Spastic	82
5	24	F	Spastic	85
6	43	F	Spastic	89
7	76	F	Spastic	90
8	62	M	Hypokinetic-spastic	95

[a]Percent of words correct.

Acquisition of Strategy Ratings and Intelligibility Data

Listeners completed the experiment individually in a sound-attenuating booth. They were seated directly in front of a 48.2 cm flat-panel computer monitor that had an attached external speaker. An in-house computer program was used to deliver the experimental stimuli and store the transcriptions and listening strategy responses generated by listeners. The peak output of speech stimuli was set to approximately 75 dB SPL from where listeners were seated and was calibrated periodically. Listeners heard each sentence twice. To ensure against an order effect, sentences were presented in random order so that no two listeners heard the stimulus sentences in the same order. In addition, the strategy questions were also presented in random order following transcription of the 70 stimulus sentences.

Listeners orthographically transcribed speech samples produced by speakers with dysarthria and provided ratings of listening strategies employed during transcription using the Klasner and Yorkston (2005) scale. Ten different listeners heard each of the eight speakers with dysarthria, following previous studies of a similar nature, (Beukelman et al., 2002; Garcia & Cannito, 1996; Hanson & Beukelman, 2006; Hustad, 2006). Listeners were instructed that they would complete one task in which they would hear a person with a speech impairment producing a series of sentences. Their job was to type what they thought the speaker said for each sentence. Listeners were told that speakers would be producing real words and to take their best guess

if they were unsure as to what the speaker said. They were also informed that they would be answering a series of questions regarding what they did when they listened to the speaker, after transcribing all 70 sentences. Listeners were provided with instructions on how to use the experimental software to advance through the experiment. In addition, they viewed two sample sentences, which were taken from the SIT, to familiarize themselves with the experimental paradigm.

Dependent Measures and Experimental Design

The dependent variable for this study was strategy ratings by the listeners, which were obtained using the 24-item listening strategy scale developed by Klasner and Yorkston (2005). To examine differences in responses to individual strategy questions, ratings were pooled across speakers for each question. To examine differences among categories of strategies, ratings were further pooled across questions within each strategy category. Finally, to examine differences in strategy ratings between strong and weak listeners, ratings were pooled for the two listeners with the highest and the two listeners with the lowest intelligibility scores for each speaker, as determined by transcription intelligibility data for the 70 SIT sentences.

A $4 \times 6 \times 8$ split plot design (Kirk, 1995) was employed for this study. The four-factor within-subjects measure was Strategy Type, and its categories were Cognitive, Linguistic, Segmental, and Supragemental. The six-factor within-subjects measure was Strategy Question, with each of the six questions per category treated as a factor. The eight-factor between subjects measure was Speaker Group, with each speaker having its own group of 10 listeners.

Because the dependent measures were interval-level data, nonparametric tests were used to examine differences between ratings. Wilcoxon signed-rank tests were used to examine pair-wise differences among strategy use ratings, pooled across questions and speakers, within the four strategy groups. Six contrasts were examined, and an alpha level of .05 was partitioned using the Bonferroni procedure. Thus, a probability of .008 or less was necessary for any contrast to be considered statistically significant. Differences among individual questions within each strategy were examined descriptively to reduce the number of statistical tests performed and the subsequent probability of a type I error.

To examine differences between strong and weak listeners for each of the groups of strategies, Mann-Whitney U tests were performed. Four different contrasts were examined to determine if there were differences between strong and weak listeners within each strategy category. Again, an alpha of .05 was partitioned among these contrasts, requiring a probability of .0125 or less for significance. In addition, individual strategy questions for which endorsement rating were greater than 3.0 or less than 2.0 (for either the strong or weak listeners) were also examined using Mann-Whitney U tests to determine if there were differences between strong and weak listeners. An alpha level of .05 was, again, partitioned among these contrasts, requiring a probability of .003 or less for significance.

RESULTS

Overall Strategy Use

Descriptive results for each of the four categories of strategies across speakers, shown in Figure 1, indicate that cognitive strategies had the highest endorsement ratings, followed by linguistic, segmental, and suprasegmental. To evaluate the magnitude of endorsement ratings, operational definitions of strong endorsement and dis-endorsement were established. Strategies and categories of strategies with mean ratings greater than 3.0 or less than 2.0 were considered strongly endorsed or dis-endorsed, respectively. This definition allowed us to focus our analyses on examination of strategies that inspired strong affirmative or negative responses from listeners, with less emphasis on strategies for which preferences were less clear (averages between 2.0 and 3.0). Using these criteria, only the cognitive and linguistic categories were considered highly endorsed. None of the categories of strategies met our criteria to be considered highly dis-endorsed.

Nonparametric inferential statistics indicated that cognitive strategies had higher endorsement

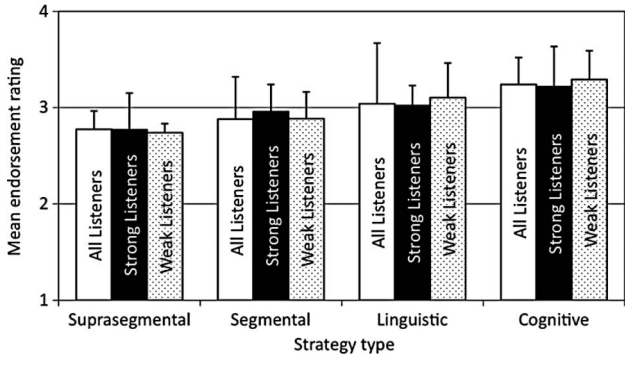

Figure 1. Mean endorsement rating by listening strategy and listener performance.
Note. Data for the strong listeners reflect the mean of the two listeners with the highest intelligibility scores; data for the weak listeners reflect the mean of the two listeners with the lowest intelligibility scores.

ratings than suprasegmental strategies ($z = -6.169$; $p < .001$), segmental strategies ($z = -5.437$; $p < .001$), and linguistic strategies ($z = -3.774$; $p < .001$). In addition, linguistic strategies had higher endorsement ratings than suprasegmental strategies ($z = -4.960$; $p < .001$), and segmental strategies ($z = -3.427$; $p \leq .001$). Finally, suprasegmental and segmental strategy endorsement ratings did not differ significantly.

Within each category, examination of constituent questions indicated that 12 of 24 questions met our criteria to be considered highly endorsed. Five of these strategies were in the cognitive category (Cog19, 20, 21, 23, and 24) (see Figure 2), four were in the linguistic category (Ling13, 15, 16, and 18) (see Figure 3), two strategies were in the segmental category (Seg02, and Seg05) (see Figure 4), and one was in the suprasegmental category (Supra08) (see Figure 5).

Strong versus Weak Listeners

Differences in strategy use between strong and weak listeners were obtained by pooling only those ratings generated by the two listeners with the highest intelligibility scores for each speaker and the two listeners with the lowest intelligibility scores for each speaker. Descriptive results are

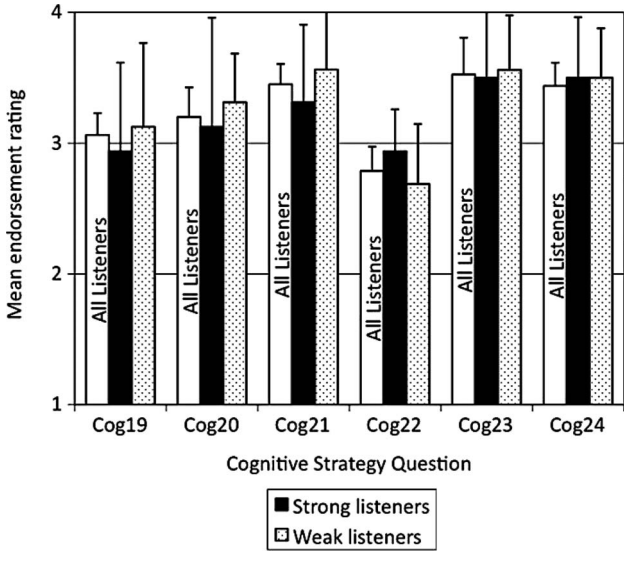

Figure 2. Mean endorsement ratings for cognitive strategies by individual question.
Note. Data for the strong listeners reflect the mean of the two listeners with the highest intelligibility scores; data for the weak listeners reflect the mean of the two listeners with the lowest intelligibility scores. Cog19 = I had to be prepared to hear distorted speech; Cog20 = I had to completely attend to the sentence to understand it; Cog21 = I used repetition of the sentence to help me remember the whole sentence; Cog22 = I guessed the meaning of the sentence based on the words I understood; Cog23 = I had to concentrate on understanding the sentence; Cog24 = I had to remember words I understood to understand the rest of the sentence.

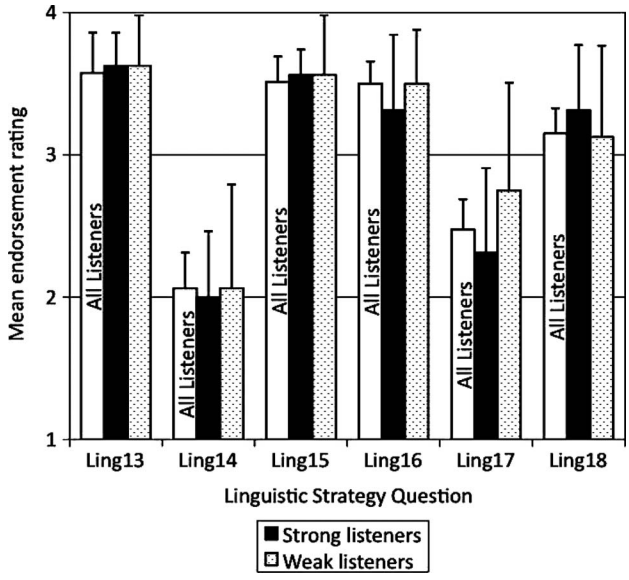

Figure 3. Mean endorsement ratings for linguistic strategies by individual question.
Note. Data for the strong listeners reflect the mean of the two listeners with the highest intelligibility scores; data for the weak listeners reflect the mean of the two listeners with the lowest intelligibility scores. Ling13 = I tried to understand the unclear words from the context; Ling14 = I added/deleted words to make the sentence make sense; Ling15 = I listened the first time and filled in the blanks the second time I listened; Ling16 = I used context to help me understand the whole sentence; Ling17 = I tried to tell if the sentence was a question or a statement; Ling18 = I tried to predict what the sentence will be based on the words I understood.

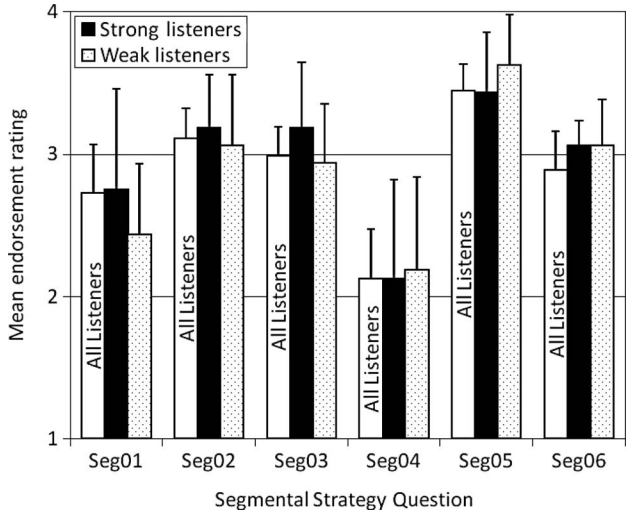

Figure 4. Mean endorsement ratings for segmental strategies by individual question.
Note. Data for the strong listeners reflect the mean of the two listeners with the highest intelligibility scores; data for the weak listeners reflect the mean of the two listeners with the lowest intelligibility scores. Seg01 = When sounds were missing, I filled in with what I thought should be there; Seg02 = I pieced fragments of words together to understand what was said; Seg03 = I tried to put the sounds together to make words; Seg04 = I wrote down what I heard without any regard to context; Seg05 = I used the sounds I heard clearly to understand words; Seg06 = I put the syllables I heard together to make the words in the sentence.

displayed in Figure 1. Results suggest that endorsement patterns for the two strongest and two weakest listeners for each speaker were similar to the grand mean across all 10 listeners, with cognitive strategies having the highest endorsement ratings, followed by linguistic, segmental, and suprasegmental.

Nonparametric inferential statistics comparing the difference between strong and weak listeners within each category of strategies indicated that mean strategy use ratings did not differ significantly for any of the categories of strategies (see Table 2). However, there was a 10% difference in intelligibility scores between the two strongest and two weakest listeners of each speaker.

Within each category of strategies, the constituent items that met our criteria to be considered highly endorsed by the strong and/or weak listeners were examined. Descriptive results are displayed in Figures 2–5. With a few exceptions, findings were very similar to mean results across all listeners. Within the cognitive category, one strategy (Cog19) that had a mean endorsement rating above 3.0 across all listeners had a mean endorsement rating *below* 3.0 for the strongest listeners. Within the segmental category, two additional strategies met our criteria to be considered strongly endorsed by the strong and/or weak listeners: Seg03 and Seg06. The difference between strong and weak listeners for each of the 12 core strategies plus the additional strategies that met out criteria (Seg03; Seg06) was not significant for any of the 14 contrasts examined (see Table 2).

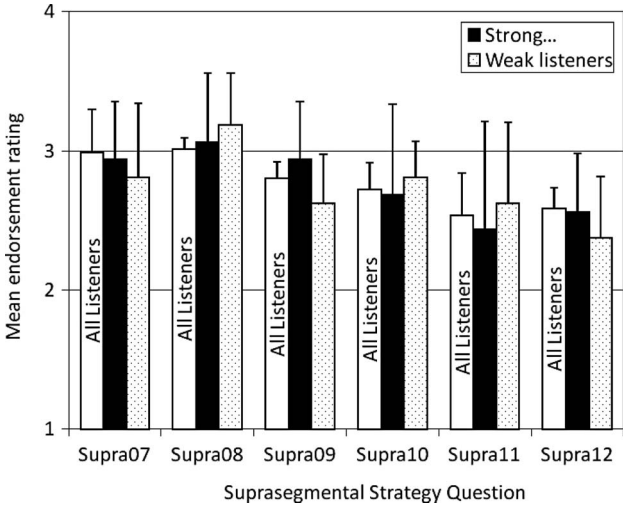

Figure 5. Mean endorsement ratings for suprasegmental strategies by individual question.
Note. Data for the strong listeners reflect the mean of the two listeners with the highest intelligibility scores; data for the weakest listeners reflect the mean of the two listeners with the lowest intelligibility scores. Supra07 = A slow rate allowed me to listen for the meaning of the sentence; Supra08 = Focusing on individual words helped me to understand the sentence; Supra09 = I tried to break up strings of sounds into words; Supra10 = I broke down the sentence into individual words to understand it; Supra11 = I tried to use the rhythm of the sentence to understand it; Supra12 = I depended on breaks between words to help me understand the sentence.

DISCUSSION

Individuals who require AAC frequently have residual speaking capability. Indeed, speech often plays an important role, along with other unaided communication modes (e.g., gestures, facial expression), in the multi-modal communication repertoire of individuals who use AAC. For adults with chronic motor speech disorders such as dysarthria one approach to maximizing speech intelligibility may be to train listeners to optimize their ability to understand the dysarthric speech signal. This study sought to examine the strategies that listeners employ when presented with the speech of individuals with dysarthria secondary to CP, and to determine if strong and weak listeners used different strategies, as indicated by the Klasner and Yorkston (2005) scale. Eight individuals with dysarthria secondary to CP participated as speakers in this study, along with 80 listeners who transcribed speech stimuli. Listeners then rated their use of each of the 24 strategies from the Klasner and Yorkston scale, using values of 4 (strongly agree, 3 (agree), 2, (disagree), 1 (strongly disagree). Listener ratings that were

TABLE 2 Difference (Strong minus Weak Listeners) in points on the Likert scale, Mean Rank for Strong and Weak Listeners, and z and p values for Mann Whitney U tests Comparing Strong and Weak Listeners' Ratings.

		Mean rank			
Contrast	Difference	Strong	Weak	*z*	*p*
Cognitive	.073	9.25	7.75	−.530	.596
Linguistic	.083	9.13	7.88	−.635	.526
Segmental	−.073	7.75	9.25	−.636	.525
Suprasegmental	−.031	8.69	8.31	−.159	.874
Ling13	.000	8.63	8.38	−.123	.902
Cog23	−.060	8.63	8.38	−.111	.911
Ling15	.000	8.63	8.38	−.122	.903
Ling16	−.188	9.38	7.63	−.773	.440
Cog21	−.250	9.50	7.50	−.877	.380
Seg05	−.188	9.56	7.44	−.955	.340
Cog24	.000	8.50	8.50	.000	1.00
Cog20	−.188	8.94	8.06	−.388	.698
Ling18	.188	7.88	9.13	−.554	.580
Seg02	.188	8.44	8.56	−.061	.951
Cog19	−.188	9.19	7.81	−.594	.553
Supra08	−.125	9.38	7.63	−.783	.434
Seg03	−.250	9.69	7.31	1.059	.328
Seg06	.000	8.56	8.44	−.069	.959

greater than 3.0 and less than 2.0 were considered meaningful, reflecting strong endorsement or disendorsement. Ratings for each question were averaged across all ten listeners for each speaker. Results across all listeners and speakers showed that two groups of strategies, cognitive and linguistic, were highly endorsed, with average ratings greater than 3.0. Furthermore, 12 individual strategies were highly endorsed. Although intelligibility scores differed for the two strongest and two weakest listeners of each speaker, use of the four types of listening strategies did not differ for the two types of listeners, nor did use of any of the 12 highly endorsed individual strategies. Results are discussed below.

Listening Strategies

As a group, cognitive strategies were the most highly endorsed by listeners of speakers with CP, followed by linguistic strategies, then segmental strategies, and then suprasegmental strategies. Only cognitive and linguistic strategies as a group had endorsement averages greater than 3.0 (of 4.0). The strong endorsement by listeners of cognitive and linguistic strategies suggests that listeners relied heavily on application of top-down knowledge when deciphering dysarthric speech. Other studies have documented the importance of top-down knowledge on intelligibility (Garcia & Cannito, 1996; Hustad, 2007a, b), so this is not new information. However, what is new from the present study is listeners' *awareness* of their use of such strategies. These findings differ from those of Klasner and Yorkston (2005), who examined speakers with dysarthria secondary to ALS and HD. In particular, the descriptive ranking of strategy categories for speakers with HD (from most to least endorsed) was suprasegmental, cognitive, segmental, and linguistic. It is interesting to note that average endorsement ratings were not greater than 3.0 for any category of strategies for listeners of speakers with HD. For listeners of speakers with ALS, the descriptive ranking of strategy categories, again from most to least endorsed, was cognitive, segmental, suprasegmental, and linguistic. For speakers with ALS only the cognitive and segmental categories had average endorsement ratings that were greater than 3.0. There are several possible explanations for the differences between the Klasner and Yorkston study and the present study; these are discussed below.

In the present study, there were 12 individual core strategies, defined by average endorsement ratings of 3.0 or greater, which were used by listeners of speakers with dysarthria. Core strategies comprised items from each of the four categories – cognitive, linguistic, segmental, and suprasegmental – with the majority being cognitive and linguistic in nature.

Five of the 12 core strategies were from the cognitive category. The most highly endorsed of these (M rating = 3.5; rank = 2) was Cog23 (I had to concentrate on understanding the sentence), suggesting that concentration was one of the most important variables when processing dysarthric speech (see Figure 2).

Four of the 12 core strategies were from the linguistic category. The most highly endorsed of these (M rating = 3.6; rank = 1) was (Ling13 I tried to understand the unclear words from the context), suggesting that listeners made deliberate use of top-down contextual information to decipher individual words (see Figure 3). This finding is consistent with other studies showing that listeners rely on linguistic-contextual information when listening to dysarthric speech.

Two of the 12 core strategies were from the segmental category. The most highly endorsed of these (M rating = 3.45; rank = 6) was Seg05 (I used the sounds I heard clearly to understand words); only one of the 12 core strategies was suprasegmental (Supra08 Focusing on individual words helped me to understand the sentence) (M rating = 3.01; rank = 12). It is interesting to note that the suprasegmental strategy had the lowest endorsement rating of all strategy statements (see Figures 4 and 5). The 12 core individual strategy statements, their mean ratings and their rankings are provided in Table 3.

Findings from the present study regarding endorsement of individual strategy questions bear both similarities and differences to the results of Klasner and Yorkston (2005). Klasner and Yorkston examined only the top 10 rank-ordered strategies for listeners of speakers with ALS and HD, based on mean endorsement ratings. Therefore, only the 10 most highly endorsed strategies from the present study will be compared with their results. As shown in Table 3, 7 of the 10 highest ranked strategies in the present study overlapped with the findings of Klasner and Yorkston across their two groups of speakers. Of those 7 strategies, 3 were common for listeners of speakers with CP, ALS, and HD; 2 were cognitive; and 1 was segmental. In addition, 2 strategies were common between listeners of speakers with CP and listeners of speakers with HD: both were from the linguistic category. Two strategies were also common between listeners of speakers with CP and listeners of speakers with ALS: 1 was cognitive and 1 was segmental. Finally, 3 strategies were unique to listeners of speakers with CP: 2 were linguistic and one was cognitive. Collectively, these findings suggest that there may be a small

TABLE 3 Twelve Core Listening Strategies that were Highly Endorsed (with mean Ratings Greater than 3.0 of 4.0) by Listeners of Speakers with CP.

Strategy	Category	Strategy number	*M* rating (*SD*)	Rank order
I tried to understand the unclear words from the context.	Linguistic	13	3.57 (.17)	1*
I had to concentrate on understanding the sentence.	Cognitive	23	3.53 (.21)	2**
I listened the first time and filled in the blanks the second time I listened.	Linguistic	15	3.51 (.16)	3#
I used context to help me understand the whole sentence.	Linguistic	16	3.50 (.19)	4*
I used repetition of the sentence to help me remember the whole sentence.	Cognitive	21	3.45 (.19)	5*
I used the sounds I heard clearly to understand words.	Segmental	05	3.45 (.18)	6**
I had to remember words I understood to understand the rest of the sentence.	Cognitive	24	3.44 (.18)	7†
I had to completely attend to the sentence to understand it.	Cognitive	20	3.20 (.25)	8**
I tried to predict what the sentence would be based on the words I understood.	Linguistic	18	3.15 (.18)	9#
I pieced fragments of words together to understand what was said.	Segmental	02	3.11 (.21)	10†
I had to be prepared to hear distorted speech.	Cognitive	19	3.06 (.28)	11
Focusing on individual words helped me to understand the sentence.	Suprasegmental	08	3.01 (.08)	12

*Observed only in the current study (speakers with CP).

**Observed in the current study (speakers with CP) and in speakers with ALS and HD, per Klasner and Yorkston (2005).

#Observed in the current study (speakers with CP) and in speakers with HD, per Klasner and Yorkston (2005).

†Observed in the current study (speakers with CP) and in speakers with ALS, per Klasner and Yorkston (2005).

core set of strategies that are common across listeners and that listeners may fine-tune their strategy use based on the characteristics of the speech signal with which they are presented. Neither the present study, nor the Klasner and Yorkston study quantified features of the speech signal for individual speakers, beyond clinical perceptual descriptions. Based on what is known at the present time, therefore, it is not possible to draw conclusions regarding listening strategies that may be specific to particular dysarthria subtypes, acoustic features, or perceptual attributes of speech.

One key difference in the findings between the present study and that of Klasner and Yorkston (2005) is the prominence of linguistic strategies in the present study. In particular, the top-ranked strategy was linguistic, and an additional three linguistic strategies were ranked within the top 10; in the Klasner and Yorkston study, only two linguistic strategies were ranked in the top 10 and these were only endorsed by listeners of speakers with HD. Another difference is the relative non-prominence of suprasegmental strategies in the present study, with none of the suprasegmental strategies ranking in the top 10.

There are several possible explanations for the different findings between the present study and the Klasner and Yorkston (2005) study, most of which relate to methodological differences. For example, although both studies asked listeners to complete the same listening strategy scale, the events that preceded and followed completion of the scale differed. In the present study, listeners transcribed multiple sentences, all produced by the same speaker, and then completed the strategy scale one time after all transcription was completed. In the Klasner and Yorkston study, listeners completed the strategy scale 10 different times, once following transcription of each of 10 individual sentences, each of which were produced by a different speaker with dysarthria. Thus, responses from listeners in the present study may reflect gestalt strategy use aggregated across sentences but specific to only one speaker. Responses from listeners in the Klasner and Yorkston study may reflect gestalt strategy use across speakers but specific to only one sentence per speaker.

It is also noteworthy that, in the present study, listeners were not given any feedback regarding the accuracy of their transcriptions. Nonetheless, previous studies have demonstrated that, even in the absence of any type of feedback, repeated practice at transcribing the speech of one individual with dysarthria can result in significant improvements in intelligibility over time (Hustad & Cahill, 2003). In the present study, the strategy scale was completed after all sentences had been transcribed; thus, ratings may reflect the end product of any learning or perceptual adaptation that may have occurred. Klasner and Yorkston (2005) required listeners to compare their transcription of each sentence to a key containing the target sentence produced by the speaker prior to completing the strategy scale for each of the 10 sentences. Studies have demonstrated that significant intelligibility improvements occur when listeners receive feedback or training in the form of written transcripts (Liss et al., 2002). Data concerning changes in intelligibility scores and strategy scale ratings that may have occurred with learning in the Klasner and Yorkston study are not available, so

that the extent of potential learning is unknown. However, Liss and colleagues have suggested that use of orthographic transcripts may have a particularly beneficial effect on segmental level performance. The high level of endorsement of segmental strategies in the Klasner and Yorkston study may be construed as one type of evidence for this.

Strong Versus Weak Listeners

There were no significant differences between endorsement ratings of listeners with the highest and lowest intelligibility scores (strong and weak listeners, respectively) within strategy categories or among the individual strategies comprising the core of 12 that were highly endorsed. Indeed, patterns of endorsement for the strong and weak listeners were generally quite consistent with patterns across all listeners, and yet there were clear intelligibility differences between the two groups of listeners (weak listeners had average intelligibility scores of 79%; strong listeners had average intelligibility scores of 89%). There are several possible explanations for these findings.

Perhaps the most obvious explanation is that Klasner and Yorkston's (2005) scale is not sensitive to or does not query the characteristics of listeners that result in higher or lower intelligibility scores. Indeed, the scale was not developed with this in mind. Rather it was developed more broadly to understand barriers and strategies of everyday listeners. One solution would be to develop a similar type of scale that focuses explicitly on understanding what the strongest and weakest listeners do when presented with dysarthric speech.

Another issue relates to the means by which the strong and weak listeners were determined. In the present study, we examined the two best and two worst listeners as indicated by intelligibility scores for each speaker. However, several different analyses were conducted, including an examination of listeners who were more than one standard deviation above or below the mean for each speaker; results were nearly identical to those reported here. This finding provides further support for the notion that the strategy scale was not sensitive to important differences between the strongest and weakest listeners.

Intelligibility findings clearly demonstrate that there are differences between strong and weak listeners from a quantitative performance perspective. Additional work is necessary to understand how those performance differences might translate to perceptual strategies that could be exploited as interventions.

Limitations

There were several limitations to this study that may reduce its clinical utility. For example, all of the speakers who participated had mild-moderate dysarthria secondary to CP and relatively good intelligibility. Listeners of speakers with more severe dysarthria may employ additional or different strategies than those identified here. Caution should be exercised in generalizing findings of this research beyond speakers with mild-moderate dysarthria.

Listeners were relatively young and homogeneous with regard to experience and education. Other types of listeners who vary in experience, age, and hearing status may employ different strategies when listening to speakers with dysarthria.

This study used the strategy scale developed by Klasner and Yorkston (2005). The scale was developed using both qualitative and quantitative methodologies based on the speech of individuals with dysarthria secondary to ALS and dysarthria secondary to HD. In particular, strategies were identified using focus groups comprised of people who listened to speakers from the two etiology groups and then identified barriers and strategies. The scale was developed from the conclusions reached by the focus groups and then was pilot-tested on a second group of listeners. In the present study, we used the same scale to examine strategies used by listeners of speakers with dysarthria secondary to CP.

Our findings were similar to those of Klasner and Yorkston (2005) with regard to use of cognitive strategies; however, speakers similar to those in the present study were not included in the development of the scale, and it is possible that there may be other strategies, not queried on the scale, used by the listeners in the present study. Future research should examine the impact of etiology, type of dysarthria, and production features of speech on strategies employed by listeners.

Clinical Implications and Considerations for AAC Users

Results of this study suggest that there were 12 core strategies that were highly endorsed by listeners who heard extended recitation-format speech samples of individuals with dysarthria secondary to CP. These strategies were primarily cognitive and linguistic in nature, but segmental and suprasegmental strategies were also represented, although to a lesser extent. Findings are similar to those of Klasner and Yorkston (2005) with regard to the use of cognitive strategies.

Results of this study have potential implications for individuals who use multimodal

communication strategies that include both speech and AAC systems. In particular, the findings of this study may aid in decision-making regarding the use of different modes of communication in different contexts. For example, results suggest that, because listeners tend to endorse cognitive and linguistic strategies most highly, speech intelligibility should be optimized in situations where listeners are effectively able to employ strategies such as concentration, and capitalize on linguistic context. This might include quiet one-on-one situations and situations where communication interchanges have some predictability to them. In other situations, where listening strategy use might be impeded (i.e., in competing noise or where partners are communicating novel or less predictable information), the use of AAC systems and strategies may be necessary as a primary communication modality. Furthermore, it may be useful to instruct unfamiliar listeners in the use of specific cognitive and linguistic strategies when listening to speakers with dysarthria secondary to CP in order to optimize speech intelligibility. Development of listener training protocols that include instruction in listening strategies for enhancing intelligibility may have promise as an intervention approach.

Although this study examined only speakers with dysarthria and CP and everyday listeners, use of the strategies described here may be applicable to other populations with reduced intelligibility such as individuals with hearing impairment, laryngectomy, or who speak English as a second language. Additional research is necessary to determine the extent to which findings may apply to other populations.

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Notes

1 Note that in this context (and throughout the paper), the term *endorse* is used to refer to the extent to which listeners support or agree with the strategy statement.
2 Marantz America, Inc., 100 Corporate Drive, Mahwah, NJ 07430-2041.
3 Countryman Associates, Inc., 195 Constitution Drive, Menlo Park, CA 94025.

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APPENDIX

Listener Strategy Scale from Klasner and Yorkston (2005)

Category		Item
Segmental	1	When sounds were missing I filled in what I thought should be there
	2	I pieced fragments of words together to understand what was said.
	3	I tried to put the sounds together to make words.
	4	I wrote down what I heard without any regard to context.
	5	I used the sounds I heard clearly to understand words
	6	I put the syllables I hear together to make the words in the sentence.
Suprasegmental	7	A slow rate allowed me to listen for the meaning of the sentence.
	8	Focusing on individual words helped me to understand the sentence.
	9	I tried to break up strings of sounds into words.
	10	I broke down the sentence into individual words to understand it.
	11	I try to use rhythm of the sentence to understand it.
	12	I depended on breaks between words to help me understand the sentence.
Linguistic	13	I tried to understand the unclear words from the context.
	14	I added/deleted words to make the sentence make sense.
	15	I listened the first time and filled in the blanks the second time I listened.
	16	I used context to help me understand the whole sentence.
	17	I tried to tell if the sentence was a question or a statement.
	18	I tried to predict what the sentence would be based on the words I understood.
Cognitive	19	I had to be prepared to hear distorted speech.
	20	I had to completely attend to the sentence to understand it.
	21	I used repetition of the sentence to help me remember the whole sentence.
	22	I guessed the meaning of the sentence based on the words I understood.
	23	I had to concentrate on understanding the sentence.
	24	I had to remember words I understood to understand the rest of the sentence.