INFLUENCE OF 'LISTENING COMPETENCE' ON THE 'SPEECH INTELLIGIBILITY' ASSESSMENT OF PERSONS WITH DYSARTHRIA

[1]Hijas Mohamed, [2]Mahesh B.V. M. & [3]Manjula R.

Abstract

Various factors such as listeners' familiarity & experience with disordered speech, listener's comprehension, ability to predict and the cues provided by the context are considered to be crucial in the the assessment of speech intelligibility in persons with dysarthria. This study addressed the issue of listening competency in normal hearing listeners and its effects on predictability of target words embedded in sentences in naturally degraded speech samples of persons with dysarthria & artificially degraded sample (where distortion was added to the speech of a model speaker). In Experiment 1, thirty normal hearing adults rated the 38 High predictable (HP) and 38 Low predictable (LP) sentences in non degraded and artificially degraded conditions of stimuli produced by a 'model speaker'. In Experiment 2, normal hearing adults rated the intelligibility of the naturally degraded speech samples of 3 persons with dysarthria. Experiment 1 revealed that the mean scores of HP sentences were better & statistically significant compared to LP sentences and the overall combined mean scores of non degraded and artificially degraded stimuli of HP sentences were better compared to the LP sentences. Experiment 2 revealed that the mean scores of HP and LP sentences produced by persons with dysarthria was significantly different. The scores in the HP context of the 'model speaker' (degraded condition) was similar to HP score of the first and third sample of the persons with dysarthria. The LP sentence of the 'model speaker' was similar to the LP score of the third sample of the person with dysarthria. The listening competence amongst the listeners varied across degraded and non degraded HP and LP sentence contexts and the degraded LP sentences were sensitive in evaluating the listening competence of normal listeners' as it was devoid of all the contextual cues for the assessment of speech intelligibility, rendering the task difficult, thus having good potential in tapping the listeners competence.

Keywords*: Speech Intelligibility, Listening Competence, Predictability, Dysarthria*

Speech Intelligibility' is defined as "the degree to which a speaker's message can be recovered by a listener" (Kent, Weismer, Kent & Rosenbek, 1989). Assessment of speech intelligibility is a dyadic phenomenon because it assesses for listener's ability to understand the spoken messages that are produced by a speaker. Speech intelligibility is reduced in individuals with dysarthria, as a result of which their ability to convey the messages accurately is compromised (Yorkston, Beukelmen, Strand & Bell, 1999; Duffy, 2005).

Different measures including objective and subjective methods have been used to quantify speech intelligibility in persons with dysarthria. The subjective measures incorporate qualitative judgment of the speech sample of clients with dysarthria by the listeners. But these subjective measures are reported to have poor validity and reliability (Schiavetti, 1992). As an alternative to subjective measures, objective measures have been used where the listener transcribes the target words produced by the persons with dysarthria.

Many factors including signal or speaker variables and listener dependent variables influence the assessment of speech intelligibility by the listeners. Studies have shown that the accurate recognition of words produced by speakers depends on test items and elicitation procedures (Weismer, Jeng, Laures, Kent & Kent, 2001); speaker variables (Dagenis, Watts, Turnage & Kennedy, 1999) listening situation (Barkmeier, Jordan, Robin & Schum, 1991; Hustad & Cahill, 2003; Hustad, 2006); message length (Yorkston & Beukelmen, 1981), contextual cues (Hunter, Pring and Martin, 1991) and listener characteristics like age, experience, familiarity, and comprehension (Yorkston & Beukelmen, 1983; Tjaden & Liss, 1995a; Dagenis, Watts, Tarnage & Kennedy, 1999; King & Gallegos-Santillan, 1999).

Few studies have addressed the personal attributes of listeners who rate the speech intelligibility. Lindblom (1990a, 1990b) suggested that some of the listener dependent variables like experience, context, expectation and familiarity play a crucial role in the

[1]Student, All India Institute of Speech and Hearing (AIISH), Mysore-06, Email: hijasmohamedn@gmail.com, [2]Junior Research Fellow, AIISH, Mysore-06, Email: maheshslp@gmail.com & [3]Professor in Speech Pathology, AIISH, Mysore-06, Email: rmanjula08@gmail.com

understanding of a spoken message. A null relationship between familiarization and sentence transcription was evident when listeners were provided with varying periods of exposure to the speech of the persons with dysarthria (Yorkston & Beukelman, 1983; Garcia & Cannito, 1996). In contrast to this observation, Tjaden and Liss (1995a) found good agreement between period of speech familiarization training and sentence transcription in listeners.

Another factor of interest in the assessment of speech intelligibility is that of listener's comprehension of spoken messages. The method of assigning speech intelligibility ratings based on transcribed samples is questioned as to its adequacy in assessing the actual deficits in the spoken language. An alternative approach is to assess the listener's comprehension. Listening comprehension is defined as the extent to which a listener understands the intended messages spoken by a person with dysarthria (Weismer & Martin, 1992). Listening comprehension is evaluated for listener's ability to answer questions related to the content of a message (Drager & Reichle, 2001) or by asking the listeners' to summarize the content of a narrative passage (Higginbotham, Drazek, Kowarsky, Scally & Segal, 1994). Beukelman and Yorkston (1979) studied the relationship between "information transfer" (comprehension) and speech intelligibility of nine speakers with varying severity of dysarthria. The listeners had to complete two tasks, one in which they had to transcribe a paragraph and in another, they had to answer questions after comprehending the content of the paragraph produced by a group of speakers with dysarthria. Significant positive relationship was observed between "information transfer" and intelligibility. However, the results could not be generalized since both the variables were correlated with severity. A similar study by Hustad and Beukelman (2002), found a non significant relationship between speech intelligibility and comprehension when a sample of four persons with severe dysarthria was used. Another important variable in the assessment of speech intelligibility is the influence of distortion in the speech signal on listening. Many of these reports come from studies in the area of speech synthesis wherein a synthesized degraded speech and the speech of person with dysarthria are considered to be similar because both are: (a) not natural, & (b) are acoustically degraded in nature. Comprehension of stimuli in synthesized speech tokens is difficult because of the absence of speaker or cross-speaker reference, segment realization and variability in word environment (Eisenberg, Shannon, Martinez, Wygonski & Boothroyd, 2000).

Many studies have cited variables such as familiarity, experience and context as being crucial in determining the listeners' rating of speech intelligibility of persons with dysarthria (Yorkston & Beukelmen, 1983; Tjaden & Liss, 1995a; Dagenis, Watts, Tarnage & Kennedy, 1999; King & Gallegos-Santillan, 1999). Most of these studies, however, have not addressed the issue of *listening competence* of listener. 'Listening competence' is presumed to be the same across all participants who are 'normal' while measuring speech intelligibility which is not necessarily true. Listening competence has a bearing on the allocation of cognitive resources in the individual, which in turn reflects on how exactly they rate the intelligibility of a spoken message. Few studies have suggested a wide variability within normal listeners with respect to speech intelligibility rating of distorted speech signal (Eisenberg, Shannon, Martinez, Wygonski & Boothroyd, 2000) and recognition of voices after voice identification training (Nygaard & Pisoni, 1998). A similar trend can be expected in normal listeners when they evaluate the speech intelligibility of persons with dysarthria, since their speech is distorted as a factor of the disorder in question. The present study is an attempt to understand the influence of *listening competence* of normal listeners on the rating of speech intelligibility of persons with dysarthria.

Need for the study

Studies on the assessment of speech intelligibility of persons with dysarthria have focused on listener dependent variables such as listeners' familiarity with disordered speech, work experience, contextual information that is associated with the spoken message and listener's comprehension of the spoken message (Beukelman & Yorkston, 1979; Higginbotham et al., 1994; Nygaard & Pisoni, 1998; Eisenberg et. al., 2000; Drager & Reichle, 2001). The issue of variability within listeners with respect to their listening competence is not addressed. The influence of listening competence in assessing the speech intelligibility of degraded speech samples of normal individuals has not been explored. Although, there are very few studies which have addressed the influence of contextual environment of stimuli words on the rating of speech intelligibility (Miller, Hiese & Lichten, 1977; Yorkston & Beukelman, 1981, 1983) only few have looked into the factor of predictability of occurrence of a given word in a linguistic context, the effect of frequency of occurrence of a given word in the language and other linguistic variables (Kalikow, Stevens & Elliott, 1977). The present study attempts to analyze the performance of normal listeners in speech

identification task involving 'high predictable' and 'low predictable' words in sentential context of non degraded and degraded situation and comparison of the same with the scores of intelligibility of the speech of persons with dysarthria. The specific questions raised is with respect to the competence of the listeners in decoding the high and low predictable words presented in sentence context (degraded and non degraded) and its influence over the rating of naturally degraded speech like that of persons with dysarthria.

Aims of the study: The study aimed to analyze and compare the listening competence of normal listeners as reflected in the assessment of speech intelligibility of stimuli consisting of High and Low predictable words spoken by a 'model speaker' in a sentential context that is presented in non degraded and degraded conditions with the performance of listeners' in the assessment of speech intelligibility of naturally degraded speech produced by persons with moderate to severe dysarthria.

Method

Participants

Two groups of participants and a model speaker (M) were included in the experiment

Group I: Listeners

A total of 30 normal adults constituted the listeners group. Of this, twenty two were males and eight were females in the age range of 17-25 years (mean age of 20.16). All the participants had studied in an English medium educational set up for a minimum of 10 years. They were screened for any type of hearing impairment, speech and language problems. It was also ensured that none of the participants were formally trained / had participated in the analysis of speech samples of any type. No attempt was made to balance the gender of the listeners since it was not a variable of interest in the study.

Group II: Speakers with Dysarthria

To select participants only with moderate degree of dysarthria, a narration sample on daily routine was recorded consisting of a minimum of hundred words from 5 persons with dysarthria. The recorded samples were analyzed by the investigators for Percentage Consonant Correct (PCC) (Shriberg & Kwiatowski, 1982). Only those individuals with a PCC score of <65%, suggesting a moderate to severe speech problem were included in the study. Based on the criteria set for PCC, three speakers with moderate degree of dysarthria were included in the age range of 15-55 years (mean age of 33 years). Of these, two were males and one was a female. The presence of receptive & expressive language deficits in the participants was ruled out by administering Western Aphasia Battery (Kertesz, 1982) and also by clinical examination.

Model speaker

A 22 year old male was selected as a 'model speaker' in the study. The stimuli (sentences with embedded stimuli words of high and low predictability) were spoken by the model speaker.

Material

Construction of the test sentences

The speech stimuli used in the experiment consisted of 38 High Predictable (HP) and 38 Low Predictable (LP) words (refer Appendix I) embedded in sentences which were adapted from Speech in Noise Perception Test (SPIN), (Kalikow & Elliot, 1977). In the HP sentence type, the final words in the sentence were highly predictable based on the context of the preceding words of the sentence (e.g., My T.V. has a twelve-inch *screen)*. In the LP sentence type, the final words in the sentence were least predictable based on the context of the preceding words of the sentence (e.g., Peter should speak about the *mugs*). Since the original test stimuli in SPIN test had target words in the final position of the sentence which were appropriate to western population, modifications were done by replacing the target words at the end of the sentences of SPIN test with words which were found to be suitable for the Indian population in a pilot study.

Pilot study

A pilot study was carried out to modify the target words to suit the Indian population. Seventy Six (76) sentences (38 each for HP words and LP words in the end) were formed taking care that the sentences were applicable to Indian context, but the last word of the sentence was kept blank. Three judges (post graduates in Speech-Language Pathology) who were proficient in English Language were selected. These judges were instructed to fill in the blanks with the most appropriate words. Later, the target words provided by the three judges were examined by the investigators and the most appropriate words that suited the Indian context were chosen for the final recording.

Procedure

Experiment 1: ***Recording Speech Stimuli***

The model male speaker was asked to read the selected target sentences (76 sentences with 38 HP and 38 LP sentences). He was instructed to read the sentences as naturally as possible with natural/habitual, prosody, loudness and pitch. The recording was carried out in a sound treated room using a professional digital sound recorder. The model speaker read out the HP sentences followed by the LP sentences. An interval of 4 seconds was maintained between each sentence and a time gap of 5 minutes was provided between the recordings of HP and LP sentences. The 76 recorded sentences were utilized to create two sets of sentences (with two conditions of HP and LP in each set) as follows:

Set 1 consisted of 76 sentences (38 HP target words at the end and 38 LP target words at the end). The set 1 sentences were used in the experiment as a non distorted set.

Set 2 consisted of 76 sentences (38 HP target words at the end and 38 LP target words at the end) but were subjected to distortion (only on the HP and LP target words). The distortions on the target words in Set 2 were created by superimposing 1 dB white noise on the HP and LP target words at the end of sentences, using *Cool Edit Program (Styrillium Co. Inc., 1999*). The words in the rest of the sentence (other than the terminally placed HP and LP words) were not subjected to any distortion.

In total, set 1 consisted of 38 non degraded HP sentences (NDHP) and 38 non degraded LP sentences (NDLP), set 2 consisted of 38 HP degraded sentences (DHP) and 38 LP degraded sentences (DLP). The stimuli in the experiment 1, thus included 152 token sentences [38 HP + 38 LP in Set 1(non degraded) and 38 HP + 38 LP in Set 2 (degraded)].

Listening task 1

Group 1 participants who served as listeners were presented with 152 token sentences (randomized across degraded and non degraded condition and across HP and LP conditions). The participants were comfortably seated in a room with no distraction. The stimuli were delivered through headphone via digital sound recorder at comfortable loudness level to each of the listener. The listeners were instructed to listen to the sentences which were played through the digital sound recorder and identify the last word in each sentence and write them on a response sheet as heard by them. The sentences were played only once. A time gap of 15 seconds was provided between the sentences to facilitate entry of responses by the listeners on the response sheet. A gap of 5 minutes was provided four times in between the entire experiment to reduce fatigue in the participants.

Experiment 2: ***Recording Speech Stimuli from Group 2 participants (Persons with dysarthria)***

In the Experiment 2, three individuals with moderate to severe dysarthria from Group 2 were asked to read out the list of 76 sentences of set 1 (with HP and LP words in the terminal position) one by one in natural and clear manner. Since the presence of dysarthria by itself gave rise to a 'degraded like' speech signal, the speech samples were not subject to superimposition of noise as in experiment 1. It was assumed that the set 2 stimuli of experiment 1 (degraded HP and LP condition) would be equivalent to speech stimuli recorded from persons with dysarthria. Hence in experiment 2, only two conditions (DHP) and (DLP) existed. Like in experiment 1, the speech was recorded in a sound treated room using a professional digital sound recorder.

Listening task 2: Group 1 participants who served as listeners were presented the 76 sentences recorded from persons with dysarthria (randomized across HP and LP conditions). The experimental set up including instructions and recording of responses were the same as in Experiment 1.

Analysis

Each correct identification of the target word by the listeners was scored as '1' and no/incorrect response as zero. The scores for correct identification of the target words (NDHP, NDLP, DHP, and DLP) of Experiment 1 (DHP, and DLP) and Experiment 2 were noted and tabulated. The total score per listener per experiment were converted to percentage score. The group mean percentage scores for correct identification of the target sounds were computed and this was subjected to statistical treatment.

Results and Discussion

The percent correct identification of the target words were calculated for 4 different conditions in Experiment 1 and 2 conditions of Experiment 2.

Section 1: Task 1 of Experiment 1

The mean percent identification of HP sentences were higher in both non degraded and degraded conditions (Table 1). Paired t-test (Table 2)

revealed a significant difference for HP and LP sentences in non degraded context (t= 2.513, p< 0.05) and for HP and LP sentences in degraded condition (t=10.476, p<0.01). The results confirm the findings of studies which report that semantic predictiveness improves the listeners' scores of intelligibility for the speech of persons with dysarthria (Hunter, Pring & Martin, 1991; Garcia & Dagenais, 1998). The scores of HP non degraded condition was higher than that of the degraded, and this can probably be reasoned on the basis that the degraded condition reduced the contextual cues, further increasing the load on the finite cognitive resources required for the perception of the target stimulus. Similar observation is made by others (Lindblom, 1990a, 1990b; Duffy & Pisoni, 1992).

Table 1: *Percent correct identification and standard deviation of Experiment 1*

Analysis	Non Degraded Condition		Degraded Condition	
	HP	LP	HP	LP
Mean	97.88	95.60	68.35	48.56
SD	3.20	4.95	12.32	10.32

Table 2: *Paired t test values for Experiment 1*

Conditions	t-value	df	Sig. (2-tailed)
NDHP-NDLP	2.513	29	.01*
DHP-DLP	10.476	29	.00**

'' = Significant at 0.05 level of significance*
*'**' = Significant at 0.01 level of significance*

Table 3: *Mean percent correct identification and standard deviation of HP and LP conditions in Experiment 1*

Conditions	Overall Mean	SD
HP	62.9	27.5
LP	52.6	28.0

Table 4: *Paired sample t test for HP and LP conditions of Experiment 1*

Conditions	Mean	SD	T-value	df	Sig (2 - tailed)
HP-LP	10.34	10.11	12.536	149	.000*

'' = Significant at 0.01 level of significance*

The mean scores were higher for the HP sentences in all conditions compared to the LP sentences. Paired t test (Table 4) indicates that the difference between HP and LP sentences was highly significant (t=12.536. p< 0.01). The difference in the speech intelligibility scores can be attributed to the predictability of semantic content and grammatical structure of the sentences (Garcia & Cannito, 1996). Duffy and Giolas (1974) examined the intelligibility of words in sentences in which the words had various degrees of predictability. The contextual cues provided by the HP sentences helped the listeners to perceive the target stimulus accurately and on the other hand, absence of this in LP sentences did not help the listeners in identification of the stimuli words leading to poor intelligibility scores. Hence, it seems that the high and low predictable sentential contexts were sensitive in reflecting the competence of the listeners.

Section 2: Task 2 of Experiment 2

The mean speech intelligibility scores of HP sentences were higher when compared to LP sentences and significant when normal listeners assessed the intelligibility of speech of persons with dysarthria. The results are similar to that observed for Experiment 1, reiterating the observation that there is an advantage of HP condition over the LP condition.

Table 5: *Mean percent correct identification & standard deviation of speech intelligibility scores for HP and LP sentences of experiment 2*

Conditions	Mean	SD
HP	49.42	24.59
LP	39.53	21.65

Table 6: *Paired sample t-test of experiment 2*

Conditions	t-value	df	Sig. (2-tailed)
HP-LP	10.764	89	0.000*

'' = Significant at 0.01 level of significance*

Repeated measure ANOVA was run on the data to check the influence of listening competence on speech intelligibility measures (Table 7). The degraded version of high predictable speech sample (DHP) is significantly different from the naturally degraded sample of person with dysarthria (C_2DHP). But the scores for degraded DHP sample was similar to that of 2 persons with dysarthria (C_1DHP and C_3DHP) as confirmed by running the repeated measure of ANOVA. It is inferred that the listeners used similar cognitive resources to rate the speech intelligibility of the artificially degraded speech stimuli and naturally degraded speech sample.

Table 7: *Comparison of repeated measure ANOVA of DHP conditions of experiments 1 and 2*

Conditions		Mean Difference	Sig.
DHP	C_1DHP	0.40	1.00
	C_2DHP	49.82	0.00*
	C_3DHP	6.55	0.13

'' = Significant at 0.01 level of significance*

The degraded stimuli are significantly different in C_2DHP condition probably because the participant had severe speech intelligibility problems compared to first and third, although all the three were classified as having moderate to severe degree of speech impairment based on PCC scores. It is probable that the artificially degraded stimuli were not comparable when there is poor speech intelligibility in persons with dysarthria. However, this needs further verification.

Table 8: *Repeated measure ANOVA of DLP conditions of experiments 1 and 2*

Conditions		Mean Difference	Sig
DLP	C_1DLP	-8.57*	0.00*
	C_2DLP	35.96	0.00*
	C_3DLP	-0.31	1.00

'' = Significant at 0.01 level of significance*

The DLP sentences were significantly different ($p<0.001$) from all other speech samples of persons with dysarthria except for the third subject (C_3DLP). The difference obtained between DLP and C_2DLP could be attributed to poor speech intelligibility in subject two. But the speech samples of first and third subject was comparable with respect to intelligibility scores. Likewise, the degraded sentences for artificially and naturally degraded stimuli correlated with the third sample of person with dysarthria (C_3DLP). The inconsistency in the finding leads to the speculation that the listening competence might be varied in normal listeners' when degradation is superimposed on LP sentences. Some normal listeners might have failed to identify the target words in LP condition since the contextual cues provided is less in LP sentences along with a possible unknown interaction effect of intrinsic variables in the experimental conditions such as rate of speech of persons with dysarthria and the message predictability. These could have contributed to the observed inconsistencies. Another reason could be due to the induced variations because of the manipulation of the stimuli itself. In the artificially degraded speech of experiment 1, all the other words in the target sentences except the final word were kept undistorted whereas in the naturally degraded speech of experiment 2, all the words of a sentence were degraded. This could also be attributed to the poor scores obtained in naturally degraded stimuli compared to artificially degraded one. Though the scores of degraded sentences were different for artificially degraded and naturally degraded conditions, a correlation between the two is evident. The poorer scores in the degraded condition could be supported by the claim that the additional cognitive resources are needed to resolve ambiguous, missing, or misleading acoustic-phonetic cues which are generally present in the degraded stimuli. It is known that human beings employ finite cognitive resources and the degraded stimuli demand for a higher processing which in turn reduces the performance of listeners on degraded sentence stimuli (Duffy & Pisoni, 1992).

Table 9: *Pearson Product–Moment Correlation Coefficients for different conditions.*

		Non Degraded	Degraded	Client 1	Client 2	Client 3
Degraded	Pearson Correlation	.219	1	.673**	.334**	.600**
	Sig. (2-tailed)	.092	-	.000	.009	.000
	N	60	60	60	60	60

*** = positively correlated*

Pearson Product- Moment correlation of artificially degraded condition with all other stimuli conditions of experiment 1 & 2 was carried out (Table 9). There is a positive correlation between the degraded stimulus and the speech samples of persons with dysarthria. This suggests that speech intelligibility ratings for artificially degraded stimuli were comparable to that of naturally degraded speech samples of persons with dysarthria. However, caution needs to be exercised while commenting on the competence of normal listeners across degraded low predictable sentences, since there is a significant difference between performance with artificially degraded stimuli and that of moderate to severe speech intelligibility deficit of persons with dysarthria (C_1DLP & C_2DLP) (Table 8). Also, the difference between the artificially degraded speech stimuli and naturally degraded sample of C3 which is statistically non significant shows that there is a differential sensitivity for the low predictable speech stimuli indicating that the low predictable stimuli are sensitive and have the potential of truthfully tapping the listening competence of normal listeners. This study is carried out on a small sample (especially in the group of persons with dysarthria). It is likely that inclusion of more samples would have indicated clear trends in the listening competence.

Conclusions

Based on the performance of the listeners in the two experimental conditions, it is concluded that there exists a difference in listening competence across degraded and non degraded high and low predictable sentential context. The degraded HP speech stimuli of persons with dysarthria are similar to the artificially induced degradation of speech stimuli. The influence of listening competence is masked in the HP sentence since it is possible that the contextual cues would have helped the listener to predict the target words. Since the degraded low predictable sentences removes the contextual cues, the true listening competence is reflected in this condition. Hence LP sentences could be used to tap the listening competence of the normal listeners.

Implications

The study provides an insight into the clinical assessment of speech intelligibility task. While assessing the speech intelligibility, the listening competence of the listeners may be understood through the use of low predictable sentences. This observation is based on the outcome of the results seen in two experiments that low predictable stimuli can act as a true measure of listening competence in normal listeners. If the listening competence is not considered during the assessment of speech intelligibility, then varied results for different listeners may become evident, ultimately affecting the scores of speech intelligibility of individuals with dysarthria.

References

Barkmeier, J. M., Jordan, L. S., Robin, D. A., & Schum, R. L. (1991). Inexperienced listener ratings of dysarthric speaker intelligibility and physical appearance. In *C. Moore, & K. Yorkston (Eds.), Dysarthria and apraxia of speech: Perspectives on management*. 65–75, Baltimore,MD: Brookes.

Beukelman, D. R., & Yorkston, K. (1979). The relationship between information transfer and speech intelligibility of dysarthric speakers. *Journal of Communication Disorders, 12*, 189–196.

Dagenais, P. A., Watts, C. R., Turnage, L. M., & Kennedy, S. (1999). Intelligibility and acceptability of moderately dysarthric speech by three types of listeners. *Journal of Medical Speech-Language Pathology, 7*, 91–95.

Drager, K. D., & Reichle, J. E. (2001). Effects of age and divided attention on listeners' comprehension of synthesized speech. *Augmentative and Alternative Communication, 17*, 109–119.

Duffy, J. R. (2005). *Motor speech disorders: Substrates, differential diagnosis, and management* (2nd Ed.). St. Louis, MO: Elsevier Mosby.

Duffy, S. A., & Pisoni. (1992). Comprehension of synthetic speech produced by rule: a review and theoretical interpretation. *Language Speech, 35*, 351-389.

Duffy, J., & Giolas, T. (1974). Sentence intelligibility as a function of key word selection. *Journal of Speech and Hearing Research, 17*, 631–637.

Eisenberg, L. S., Shannon, R. V., Martinez, A. S., Wygonski, J., and Boothroyd, A. (2000). Speech recognition with reduced spectral cues as a function of age. *Journal of the Acoustical Society of America, 107*, 2704-2710.

Garcia, J., & 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 and Hearing Research, 41*, 1282-1293.

Higginbotham, D. J., Drazek, A. L., Kowarsky, K., Scally, C., & Segal, E. (1994). Discourse comprehension of synthetic speech delivered at normal and slow presentation rates. *Augmentative and Alternative Communication, 10*, 191–202.

Hunter, L., Pring, T., & Martin, S. (1991). The use of strategies to increase speech intelligibility in cerebral palsy: An experimental evaluation. *International Journal of Language & Communication Disorders*, 26, 163-174.

Hustad, K.C., & Beukelman, D.R. (2002). Listener comprehension of severely dysarthric speech: Effects of linguistic cues and stimulus cohesion. *Journal of Speech, Language, and Hearing Research, 45*, 545-558.

Hustad, K. (2006). Estimating the intelligibility of speakers with dysarthria. *Folia Phoniatrica, 58*, 217–228.

Hustad, K. C., & Cahill, M. A. (2003). Effects of presentation mode and repeated familiarization on intelligibility of dysarthric speech. *American Journal of Speech-Language Pathology*, 12, 198–208.

Kalikow, D. N., Stevens, K. N., Elliott, L. L., (1977). Development of a test of speech intelligibility in noise using sentence materials with controlled word predictability. *Journal of Acoustical Society of America, 61*, 1337-1351.

Kent, R.D., Weismer, G., Kent, J.F., & Rosenbek, J.C. (1989). Toward phonetic intelligibility testing dysarthria. *Journal of Speech and Hearing Disorders, 54*, 482-499.

Kertesz, A. (1982). *Western Aphasia Battery Test Manual*. The Psychological Corporation.

King, J. M., & Gallegos-Santillan, P. (1999). Strategy use by speakers with dysarthria and both familiar and unfamiliar conversational partners. *Journal of Medical Speech-Language Pathology, 7*, 113–116.

Lindblom, B. (1990a). Explaining phonetic variation: A sketch of the H & H theory. In W.J. Hardcastle & A. Marchal (Eds.), *Speech production and speech modeling*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Lindblom, B.(1990b). On the communication process: Speaker-listener interaction and the development of speech. *Augmentative and Alternative Communication*, 6, 220–230.

Miller, G.A., Heise, G.A., and Lichten, W. (1951). The intelligibility of speech as a function of

the context of the test materials. *Journal of Experimental Psychology, 41,* 329-335.

Nygaard, L., & Pisoni, D. (1998). Talker- specific learning in speech perception. *Perception and Psychophysics, 60*, 355-376.

Schiavetti, N. (1992). Scaling procedures for the measurement of speech intelligibility. In R. Kent (Ed.), *Intelligibility in speech disorders*, Amsterdam: Benjamins.

Shriberg, L. D., & Kwiatkowski, J. (1982). Phonological Disorders II: A Conceptual Framework for management. *Journal of speech and hearing disorders, 47,* 242-256.

Tjaden, K. K., & Liss, J. M. (1995a). The influence of familiarity on judgments of treated speech. *American Journal of Speech Language Pathology, 4*, 39–48.

Weismer, G., & Martin, R. (1992). Acoustic and perceptual approaches to the study of intelligibility. In R. Kent (Ed), *Intelligibility in speech disorders*, Philadelphia: John Benjamins Publishing Co.

Weismer, G., Jeng, J.Y., Laures, J. S., Kent, R. D., & Kent, J. F. (2001). Acoustic and intelligibility characteristics of sentence production in neurogenic speech disorders. *Folia Phoniatrica et Logopaedica, 53*, 1–18.

Yorkston, K. M., & Beukelman, D. R. (1981). *Assessment of intelligibility in dysarthric speech.* Tigard, OR: CC Publications.

Yorkston, K. M., & Beukelman, D. R., (1983). The influence of judge familiarization with the speaker on dysarthric speech intelligibility. In W. Berry (ed.), *Clinical Dysarthria* Boston, MA: College Hill Press), pp. 155–163.

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.

Appendix I

Sl. No.	High Predictable sentences	Sl. No	Low Predictable sentences
1.	The old train was powered by coal.	1.	I am thinking about the consequences.
2.	My T. V. has a twelve inch screen.	2.	Tom wants to know about the course.
3.	The boat sailed along the river.	3.	The girl talked about the jewels.
4.	She wore a feather in her cap.	4.	The girl knows about the meeting.
5.	I made a phone call from a booth.	5.	The farmer harvested this season.
6.	His boss made him work like a donkey.	6.	They did not discuss the problem.
7.	Football is a dangerous game.	7.	I had a problem with the circuitry.
8.	Drop the coin through the slit.	8.	Peter should speak about the truth.
9.	Peter should speak about the truth.	9.	I want to know about the rules.
10.	Hold the baby on your arms.	10.	Jane has a problem with the house.
11.	Tear off some paper form the book.	11.	The old man thinks about the future.
12.	The candle flame melted the wax.	12.	Ann was interested in the music.
13.	The hockey player scored a goal.	13.	Tom is talking about the promotion.
14.	They played a game of cat and mouse.	14.	Ruth's grandmother discussed the plan.
15.	A Chimpanzee is an animal.	15.	I want to speak about the incident.
16.	The doctor charged a low fee.	16.	I have not discussed the questions.
17.	The cushion was filled with sponge.	17.	You could not have discussed the doubt.
18.	Stir your coffee with a spoon.	18.	We have spoken about the deal.
19.	At breakfast he drank some coffee.	19.	She wants to talk about the guy.
20.	Banks keep their money in a locker.	20.	The old man considered the proposal.
21.	A bicycle has two wheels.	21.	You want to talk about the subject.
22.	Ann works in the bank as a clerk.	22.	She might have discussed the results.
23.	The nurse gave him the first aid.	23.	Peter knows about the accident.
24.	Kill the bugs with this pesticide.	24.	The boy can't talk about the secret.
25.	The sick child swallowed the pills.	25.	We're glad Ann asked about the misunderstanding.
26.	The swimmer dove into the pool.		
27.	We heard the ticking of the clock.	26.	Miss white thinks about the health.
28.	The team was trained by their coach.	27.	We could discuss the agenda.
29.	He got drunk in the local bar.	28.	I did not know about the match.
30.	The girl swept the floor with a broom.	29.	Nancy did not discuss the kidnap.
31.	The firemen heard her frightened scream.	30.	I am talking about the serial.
32.	The landlord raised the rent.	31.	The woman knew about the treatment.
33.	To open the jar, twist the lid.	32.	Tom won't consider the excuse.
34.	Spread some butter on your bread.	33.	The man spoke about the program.
35.	The chicken pecked corn with its beak.	34.	Miss white doe not discuss the murder.
36.	The detectives searched for a clue.	35.	I'm glad you heard about the frog's sound.
37.	Watermelon has lots of seeds.		
38.	Old metal cans were made with tins.	36.	Mr. White spoke about the engagement.
		37.	Marry has not discussed the issue.
		38.	Miss White doesn't discuss the quarrel.