LANGUAGE AND SPEECH, Vol. 24, Part 3, 1981 

# THE EFFECT OF CONTEXT ON THE INTELLIGIBILITY OF HEARING AND DEAF CHILDREN'S SPEECH*

NANCY S. MCGARR
*Graduate School and University Center*
*The City University of New York*
*and*
*Haskins Laboratories*

This study examines the effect of redundancy of information on the intelligibility of hearing and deaf children's speech. Listeners, including those experienced and inexperienced with respect to the speech of the deaf, heard two kinds of stimuli: (1) test words in sentences that varied in the amount of redundant information available, and (2) test words excised from these sentences and presented to the listeners as isolated words. For both groups of children, test words heard in sentences were perceived correctly more often than the same words heard in isolation. However, the effect of redundant information on intelligibility was opposite to that reported for adults (Lieberman, 1963). That is, in the speech of both hearing and deaf children, the scores for test words segmented from sentences with high redundancy were greater than scores for test words segmented from sentences with low redundancy. This suggests that children are not using the same production strategies as adults to assist listeners. The data also do not support the hypothesis that experienced listeners to deaf speech achieve higher intelligibility scores than inexperienced listeners by simply making better use of context.

## INTRODUCTION

Many investigators (Miller, Heise and Lichten, 1951; O'Neill, 1957; Lieberman, 1963; Pollack and Pickett, 1963; among others) have shown that a test word produced and heard in a sentence is more intelligible than the same word produced in context but later heard in isolation. Furthermore, Lieberman (1963) reported that the predictability of a sentence also affects the intelligibility of a test word produced in a sentence but heard in isolation. Specifically, Lieberman showed that words isolated from unpredictable sentences were more intelligible than words isolated from predictable sentences. Adults produced the test words in unpredictable sentences with increased intensity, increased duration, or more precise articulation than the same test words produced in predictable sentences.

* *The research on the role of listener experience in understanding the speech of the deaf was conducted by the author in partial fulfillment for the Ph.D. degree at The City University of New York. The author wishes to acknowledge the invaluable assistance of Harry Levitt and Katherine S. Harris who served as advisors to this work and also that of Carole E. Gelfer and Janet May who provided many helpful comments on this manuscript. This research was supported by Grant NH 09252 to Harry Levitt; preparation of this manuscript was supported by Grants NS 13870 and 13617 to Haskins Laboratories.*

Taken together, these results suggest evidence for a context effect in both the perception and production of speech. The listener apparently uses context in decoding a word in a sentence. Moreover, the speaker produces words more carefully in those circumstances where the listener needs additional information. While adults may use context in the perception and production of speech, it is not known if children make use of similar strategies.

Furthermore, the effect of context on perception is considered to be a particularly important factor in evaluating the intelligibility of disordered speech. For example, one would assume that context would help a listener in decoding the speech of the deaf, as it does in decoding the speech of normals. Indeed, it has been suggested that the advantage of experienced over inexperienced listeners to deaf speech may reside in their superior ability to make use of contextual cues (Hudgins, 1949; Thomas, 1963; Brannon, 1964). However, the use of context by experienced and inexperienced listeners to deaf speech has not been systematically explored.

The purpose of this study is to examine two related questions. First, do hearing children make use of the same strategy as adults in producing predictable or unpredictable sentences? Second, do deaf children make use of such a strategy? Furthermore, is the well known superiority of experienced listeners in decoding deaf speech due to a difference in their ability to use context to decode? In order to examine these questions, the intelligibility of test words was compared in two conditions: (1) test words produced in predictable or unpredictable sentences and played in sentence context, and (2) test words originally produced in sentences but excised from context, and played in isolation. The speakers were either hearing or deaf children. For the latter group, the listeners were either experienced or inexperienced with respect to the speech of the hearing impaired.

## Experimental Procedures

### *Subjects*

A group of eight hearing children were divided into two age groups, one of 8 to 10 year olds and another of 13 to 15 year olds with 2 males and 2 females in each group. All of these children had normal speech production skills.

Twenty deaf children enrolled in a school for the deaf in metropolitan New York also participated in the study. The children were equally divided into the same age and sex groups as the hearing children. All were congenitally deaf and had no handicap other than deafness. The mean pure tone average for the 20 deaf children was 98.6dB (ISO) in the better ear. The deaf children were judged by their speech supervisors to have fair, average, or good deaf speech. No child whose speech was judged totally unintelligible was included in the study.

### *Materials*

The sentences were constructed in the following manner. A test word selected from

Smith's (1972) corpus was embedded in each of 36 sentences. The test words and the vocabulary of the sentences were chosen to be within the range for deaf children 8 to 15 years old (Silverman-Dresner and Guilfoyle, 1972). Each of the 36 sentences was defined with respect to its predictability. Following Lieberman (1963), we will refer to this factor as redundancy or the amount of semantic content in the sentence. An index of redundancy was obtained for each sentence using a standard word prediction technique. Twenty undergraduates were asked to "fill in the blank" when presented with a written version of the sentence, with the test work omitted. A sentence was defined as high in redundancy if 15 or more undergraduates completed it with the same word. A sentence was defined as low in redundancy if 15 or more undergraduates selected a different word to complete the sentence. The 36 sentences divided into two groups of 18 on this criterion and the material are shown in Table 1.[1]

Each of the children recorded the full set of 36 sentences. In order to examine the effect of redundant information on intelligibility, each test word produced in a sentence was excised from the sentence for presentation to the listeners as an isolated word. These test words are referred to as segmented test words.[2] The segmented test words were obtained using the Haskins Laboratories spectrum and waveform editing system. Segmentation was accomplished using both auditory and visual cues.

*Listeners*

Twenty-four undergraduates were asked to identify the test words produced by the hearing children. These listeners had not previously participated in a study to evaluate either deaf or normal speech and did not receive any training prior to listening.

The tapes produced by the deaf children were heard by experienced and inexperienced listeners. An experienced listener was defined as having more than one year's experience in listening to the speech of the deaf. There were 60 experienced listeners including teachers of the deaf, speech pathologists, and audiologists in schools for the deaf. The number of years' experience with the deaf ranged from just over 1 year to 25 years. The mean number of years' experience was 6.8 years.

An inexperienced listener was defined as having no previous experience in hearing

[1] *The test materials were designed as part of a larger study to assess several factors believed important to the intelligibility of deaf speech. These factors included: the number of syllables in the sentence, the position of the test word in the sentence, and the effect of phonetic composition of the test word since some phonemes are more difficult for deaf children to produce than others. In the main study, the interaction between the phonetic composition of the test words and the amount of sentence context was of particular interest. Thus, because of the design constraints of the original study, the test words were not the same in the high redundancy and low redundancy sentences as they might have been if we were interested solely in extending Lieberman's (1963) work.*

[2] *The test words excised from sentence context are referred to as segmental test words in order to distinguish them from other test stimuli that were part of the original study but not of particular interest here.*

TABLE 1

Sentences recorded by the hearing and deaf children.
The test word is italicized in each sentence.

| High Redundancy | Low Redundancy |
|---|---|
| 3 Syllables | 3 Syllables |
| *Keep* quiet. | *Feed* the dog. |
| *Read* the book. | *Have* a lot. |
| Come *with* me. | You *did* it. |
| The *dog* barks. | I *need* it. |
| Comb your *hair.* | Get the *cake.* |
| That's no *good.* | This is *his.* |
| 5 Syllables | 5 Syllables |
| The *cat* chased the mouse. | They *will* come again. |
| My *name* is Nancy. | Is *that* the tall one? |
| Get your *coat* and hat. | Mother *has* the car. |
| Get your *ball* and bat. | Who wants *this* ice cream? |
| Did you brush your *teeth?* | It's easy to *hear* her.* |
| Is there no *more* milk? | He said he *could* go. |
| 7 Syllables | 7 Syllables |
| That *man* is not my father. | The *book* is on the table. |
| I *wish* I had a pony. | What *was* the name of that boy? |
| We have *food* for the picnic. | If it's *cool* I cannot go. |
| The flag is *red,* white and blue. | Is the *fat* baby crying? |
| May I have a *piece* of cake? | It is nice on a *fall* day. |
| Can you dive in *deep* water? | We will go to the *beach* today.* |

*These sentences contain an additional syllable.

deaf speech. There were 60 inexperienced listeners recruited primarily from undergraduate classes.

*Listening conditions*

The speech recordings of the deaf and hearing children were prepared in order to present the following stimuli to the groups of listeners:

1. Test words produced in sentences and presented to the listeners in sentences. Listeners were asked to write down the whole sentence, but only the test word was scored.

2. Test words produced in sentences, excised from the sentence, and presented to the listeners in isolation – segmented test words.

In each of the two conditions, the deaf or hearing speakers' samples were randomized in such a way that each listener heard only one child with no repetition of the same test word on a tape. A single hearing child's intelligibility score for either set of stimuli was an average of three undergraduate listeners' scores. A single deaf child's intelligibility score was an average of three experienced and three inexperienced listeners' scores.

## RESULTS

*The effect of context*

Fig. 1 summarizes the scores obtained for test words in sentences as a function of redundancy. Data for the adults are taken from Lieberman (1963). Since there was no interaction between redundancy and the age of the children, the data were averaged across the two age groups. Data for hearing children showed that the effect of redundancy on the intelligibility of the sentences was very small. The mean intelligibility score for test words in high redundancy sentences was 99%, and 97% for test words in low redundancy sentences.

In contrast with the results for hearing children, the intelligibility scores for the deaf speakers showed a significant context effect ($p < 0.001$). That is, scores for either experienced or inexperienced listeners were greater for test words in sentences with high redundancy than for test words in sentences with low redundancy. For experienced listeners, scores for test words in highly redundant sentences averaged 49%, for test words in sentences with low redundant information, 33%. Scores for inexperienced listeners were 38% for sentences with high redundancy, and 21% for low redundancy. This represents a gain of approximately 16% in intelligibility for both experienced and inexperienced listeners for increased redundancy.

Fig. 2 summarizes the intelligibility scores obtained for segmented test words as a function of redundancy. A difference between intelligibility scores for test words segmented from high or low redundancy sentences was found for both hearing and deaf children but the direction of this effect is opposite that shown for Lieberman's adults.

For hearing children, the mean intelligibility score for test words segmented from high redundancy sentences was 81%, for test words segmented from sentences with low

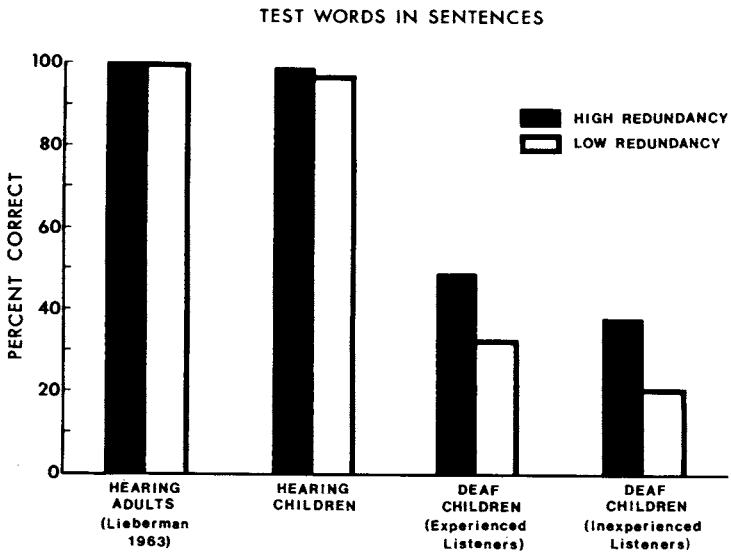


Fig. 1. Scores for test words in sentences as a function of the amount of redundant information.

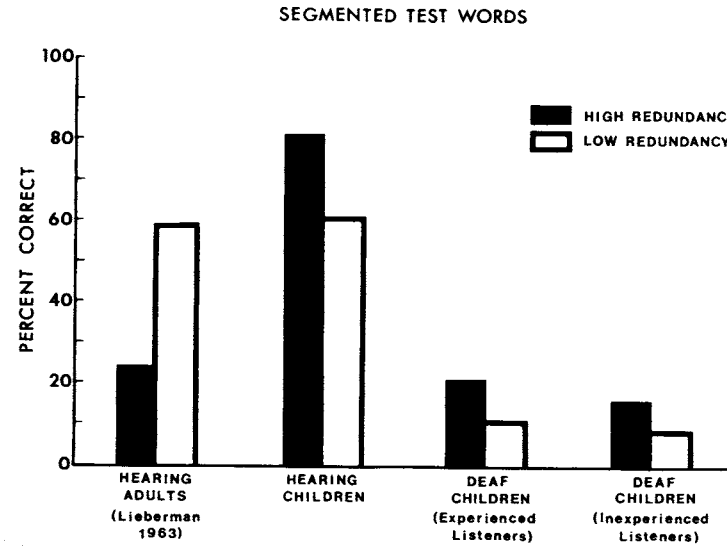


Fig. 2. Scores for segmented test words as a function of the amount of redundant information.

redundancy, 61% – a difference of 20%. Indeed, these overall scores for segmented test words are considerably poorer than those obtained for the same test words in sentences. Thus, hearing a test word in a sentence will effect a change in intelligibility even for hearing children's speech. The difference between the test words in sentences and the segmented test words was 18% for words in high redundancy sentences, and 36% for test words in low redundancy sentences. This result is similar to previous findings (Miller *et al.*, 1951; O'Neill, 1957; Pollack and Pickett, 1963).

For deaf speakers, the effect of context on the intelligibility of segmented test words is smaller than for hearing speakers but not negligible ($p < 0.001$). For experienced listeners, the mean score for test words segmented from high redundancy sentences was 21%, and from low redundancy sentences, 11%. For inexperienced listeners, scores for test words segmented from high redundancy sentences were 16%, and from low redundancy sentences, 9%. This represents an average gain of about 8% in intelligibility for both experienced and inexperienced listeners as redundancy increases.

*The differences between experienced and inexperienced listeners*

Table 2 summarizes the mean intelligibility scores for the hearing impaired children averaged across contexts for test words in sentences, and segmented test words. Scores for experienced listeners were consistently higher than those for inexperienced listeners for each type of stimulus. For both groups, scores for test words in sentences were higher than those for segmented test words. In fact, scores for test words in sentences were more than double the scores for segmented words.

The greatest difference between groups of listeners occurred for sentences. The difference between experienced and inexperienced listeners for test words in sentences was 11%; for segmented test words, it was only 3%.

In order to analyze the interaction between listener experience and context, analyses of variance were performed for each type of stimulus. These are shown in Table 3. Only those effects with a significance level of 0.01 or better were considered. Of particular interest in this study were the effects of listener experience, redundancy, and any interaction between them. Listener experience was highly significant for test words in sentences but less important for segmented test words. Redundancy of information also had a significant effect on intelligibility for both test words in sentences and segmented test words as previously noted in Figs. 1 and 2 respectively. There was no significant interaction between listener experience and redundancy for either test words in sentences or segmented test words.

## DISCUSSION

First, inspecting the data for the effect of context on perception, we find that all listeners made use of context to decode test words in the sentences of both hearing and deaf children. Intelligibility was greater for test words in sentences than for the same words produced in context but heard in isolation (segmented test words). Indeed,

TABLE 2

Mean Scores Obtained by Experienced and Inexperienced Listeners to Deaf Speech

| Stimuli | Experienced Listeners | Inexperienced Listeners |
|---|---|---|
| Test Words in Sentences | 41% | 30% |
| Segmented Test Words | 16% | 13% |

TABLE 3

Analysis of Variance for Test Words in the Sentences of Deaf Children

| Source of Variation | Sum of Squares | df | Mean Square | F | Significance |
|---|---|---|---|---|---|
| Listener Experience | 2.440 | 1 | 2.44 | 20.5 | 0.001* |
| Redundancy of Information | 6.38 | 1 | 6.38 | 53.61 | 0.001* |
| Experience x Redundancy | 0.007 | 1 | 0.007 | 0.05 | 0.80 |

Analysis of Variance for Segmented Test Words of Deaf Children

| | | | | | |
|---|---|---|---|---|---|
| Listener Experience | 0.292 | 1 | 0.292 | 5.03 | 0.025 |
| Redundancy of Information | 1.740 | 1 | 1.740 | 30.00 | 0.001* |
| Experience x Redundancy | 0.035 | 1 | 0.035 | 0.60 | 0.554 |

*Significant at $< 0.01$

for the deaf speakers, the segmented test words were only half as intelligible as the same words in sentence context. These results suggest that deaf speech like normal speech, is more intelligible in sentence context.

While there was a significant difference between experienced and inexperienced listeners to deaf speech, there was no statistically significant interaction between listener experience and context for either test words in sentences or segmented test words. Thus, these data do not suggest that experienced listeners simply make better use of contextual information than inexperienced listeners to increase overall intelligibility. Any improvement in intelligibility resulting for listener experience was essentially constant for both high and low redundancy stimuli. This lack of a statistically significant interaction does not rule out the possibility of such a context effect, but rather indicates that should such an interaction between listener experience and context exist, it is likely to be of a much smaller magnitude than previously suggested. Indeed, the results may suggest that experienced listeners to the deaf may have acquired greater skill in the perceptual analysis task itself.

Examining the effect of redundancy on production strategies, we find the direction of the context effect for the children opposite to that reported for Lieberman's adults. For either hearing or deaf children, test words segmented from high redundancy sentences were consistently more intelligible than test words from sentences with low redundancy. These results may be interpreted to suggest that the children do not use different production strategies to assist the listener with high or low redundancy sentences and may, in fact, be somewhat less accurate in producing words in low redundancy sentences. In order to investigate this notion more thoroughly, we would need to examine both perception and production data obtained with hearing and deaf children producing the same word in sentences with high and low redundancy.

The results obtained in this study are also different from what one might predict based on developmental language studies of young hearing children. Several investigations (e.g. Shatz and Gilman, 1973, 1977; Sachs and Devin, 1976) have shown that even young children seem to have acquired the communication skills necessary to adjust their language for listeners of different ages – younger children, their peers, or adults. Differences in language use reported include vocabulary, mean length of utterance, and grammatical complexity.

One would expect that if children adjust their language to accommodate the listener, they would also vary their speech production. Indeed, it is well known that when adults talk to infants or very young children, their speech production is characterized by changes in prosodic features such as higher fundamental frequency, slower rate, a more exaggerated intonation contour, etc. These different speech production strategies used by adults are believed to assist in focusing the listener's (child's) attention, to establish the social communicative nature of speech, and to facilitate language development (Garnica, 1977). Differences in the speech production skills of children as a function of the listener's age have not been examined. However, the results of this study would suggest that unlike adults, children would not show changes in prosodic features. Interestingly, there have been no studies of communicative interaction in the hearing impaired population that analyzed either their spoken or sign language. These are areas

that certainly warrant future research.

## REFERENCES

BRANNON, J.B. (1964). Visual feedback of glossal motions and its influence on the speech of deaf children. Ph.D. diss., Northwestern University.

GARNICA, O. (1977). Some prosodic and paralinguistic features of speech to young children. In C. Snow and C. Ferguson (eds.), *Talking to Children* (Cambridge).

HUDGINS, C.V. (1949). A method of appraising the speech of the deaf. *Volta Review*, **51**, 597-638.

LIEBERMAN, P. (1963). Some effects of semantic and grammatical context on the production and perception of speech. *Language and Speech*, **6**, 172-187.

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.

O'NEILL, J. (1957). Recognition of the intelligibility of test materials in context and isolation. *Journal of Speech and Hearing Disorders*, **22**, 87-90.

POLLACK, I and PICKETT, J.M. (1963). The intelligibility of excerpts from conversation. *Language and Speech*, **6**, 165-171.

SACHS, J. and DEVIN, J. (1976). Young children's knowledge of age-appropriate speech styles. *Journal of Child Language*, **3**, 81-98.

SHATZ, M. and GILMAN, R. (1973). The development of communication skills: Modifications in the speech of young children as a function of listener. *Monographs of the Society for Research in Child Development*, No. 152, 38, No. 5.

SHATZ, M. and GILMAN, R. (1977). Beyond syntax: The influence of conversational constraints on speech modifications. In C. Snow and C. Ferguson (eds.), *Talking to Children* (Cambridge).

SILVERMAN-DRESNER, T. and GUILFOYLE, G. (1972). *Vocabulary Norms for Deaf Children* (Washington, D.C.).

SMITH, C.R. (1972). Residual hearing and speech production of deaf children. Ph.D. diss., The City University of New York.

THOMAS, W. (1963). Intelligibility of the speech of deaf children. *Proceedings of the International Congress on the Education of the Deaf.* Document No. 196.