THE INTELLIGIBILITY OF ESOPHAGEAL SPEECH WITH AND WITHOUT VISUAL CUES

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ABSTRACT

The purpose of this study was to determine if the intelligibility of esophageal speech is improved by the addition of the visual component to the auditory component.

Esophageal speakers provided the recorded material which consisted of lists of phonetically balanced words recorded under audiovisual and auditory conditions. Listeners for the study were speech pathology and non-speech pathology majors.

Results indicated a significant difference between (1) scores in the audiovisual and auditory component of esophageal speech and (2) scores of speech pathology and non-speech pathology majors.

Chapter 1

INTRODUCTION

Statement of the Problem

" The person who has had his larynx surgically removed has severe voice problems that are both perceptual and acoustical (Curry: 1977)." At the initial encounter with an esophageal speaker, most people are immediately aware of the low pitch of the voice, the monotonous quality, and the reduced intelligibility (Curry: 1977).

This reduction in intelligibility has been of concern to researchers in the field of speech pathology and audiology. In the majority of these studies only auditory recordings were used to evaluate the intelligibility of esophageal speech (Lauder: 1969).

Good esophageal speech is, however, comprised of more than the physiological and acoustical components depicted in these studies. The value of visual cues in increasing the intelligibility of esophageal speech has not been adequately explored and deserves further study and measurement. Lauder (1969) believes that "esophageal speech . . . can be produced more understandably by the intelligent application of visual cues and that even

poor esophageal speakers can be taught to produce more intelligible voice by this means."

The purpose of this study was to determine if the intelligibility of esophageal speech is improved with the addition of the visual component. If this is found to be true then the application of visual cues in therapy for learning esophageal speech should be stressed.

Hypotheses

There were four null hypotheses in this study.

1. There is no significant difference between the scores in the audiovisual component and the auditory component of esophageal speech as analyzed by speech pathology majors.
2. There is no significant difference between the scores in the audiovisual component and the auditory component of esophageal speech as analyzed by non-speech pathology majors.
3. There is no significant difference between the scores of speech pathology majors and non-speech pathology majors in the analysis of words in the audiovisual component of esophageal speech.
4. There is no significant difference between the scores of speech pathology majors and non-speech pathology majors in the analysis of words in the auditory component of esophageal speech.

Review of the Literature

The population of laryngectomized patients increases each year and the life span of these patients has been extended (Diedrich: 1966). More laryngectomees are receiving speech therapy and it is essential that improved

methods be developed so that the success rate for learning esophageal speech can be raised (Snidecor: 1971). For this reason, it is important that speech pathologists know the significant aspects and characteristics of esophageal speech. The majority of studies which have been done to point out these aspects and characteristics used auditory recordings to analyze the speech. In this study, auditory and visual recordings were used. Even though the previous studies only used auditory recordings, it is important to find out what these studies yielded in order to compare the results of an audiovisual study.

Vowel Characteristics

Sisty and Weinberg (1972) examined the vowel formant frequency characteristics of esophageal speech produced by both male and female talkers. Auditory tape recordings were used to analyze the vowels. Listeners consisted of undergraduate college students with no training in phonetics or familiarity with esophageal voice and speech pathologists with training in both.

A formant frequency analysis was done on highly representative esophageal vowels selected from a listening experiment. The results of this acoustical analysis showed that: (1) female esophageal speakers had a higher mean vowel formant frequencies than males, (2) formant frequency changes from vowel to vowel were systematic and were essentially the same for normal and esophageal speakers,

and (3) average vowel formant frequency values for esophageal speakers were consistently higher than those reported for normal speakers (Peterson, Barney: 1952). The data strongly supports the hypothesis that removal of the larynx does alter vocal-cavity transmission characteristics (Sisty, Weinberg: 1972).

Christensen and Weinberg (1976) did a study on the vowel duration characteristics of esophageal speech. From the results it was found that overall vowel duration of esophageal speakers was consistently longer than those of normal speakers. Also, the duration of vowels of esophageal speakers spoken within voiceless consonants environments was consistently longer than those spoken in similiar contexts by normal speakers. Voiced consonant environments showed no significant differences with regard to the average duration of vowels spoken by normal and esophageal speakers (Christensen, Weinberg: 1976).

Effects of Masking Noise

Because esophageal speakers often state that when noise is present it adversely affects the intelligibility of their speech, Horii and Weinberg (1975) did a study to measure the intelligibility of esophageal speech under various levels of masking noise.

Broad band masking of speech was used to provide information on the effects that broad band masking noise had upon the intelligibility of consonants and vowels

produced by esophageal speakers. Procedures were developed to compare the articulation functions of superior esophageal speech with those of normal speech under comparable levels of masking noise. Articulation functions for vowels were essentially the same for esophageal and normal talkers (4% per dB), within the range of speech-to-noise ratios studied. For consonants, the intelligibility scores for esophageal speech were 12% to 14% lower than for normal speech under adverse noise conditions. Gains in the consonant articulation functions were 2.5% dB for normal speakers and 4% dB for esophageal speakers. The lowered scores for esophageal speakers for adverse noise conditions, were the result of poorer than normal intelligibility for liquid-glides and nasal, and, secondly for stop consonants. Additional differences between intelligibility characteristics of esophageal and normal speech were found in word position and voicing features (Horii, Weinberg: 1975).

Horii et al. (1971) had obtained data for normal talkers from identical experimental conditions in a previous study. He used this data to compare intelligibility of normal and esophageal speakers. Overall intelligibility functions for vowels are essentially the same for esophageal and normal speech. The intelligibility scores of consonants for esophageal speech are lower than for normal speech. The lowered consonant scores were the result of poorer than normal intelligibility for liquid-glides, nasal, and stop consonants. This supports the clinical hypothesis

that the intelligibility of speech produced by esophageal speakers is affected in adverse noise conditions.

Comparisons of Esophageal and Normal Speakers

Tikofsky (1965) was concerned with comparing the intelligibility of a population of esophageal and normal speakers. Intelligibility was determined by how many correct responses a group of listeners made to recorded speech samples. These responses were also included in the analysis to determine any significant differences in intelligibility between word lists and the order in which the lists were given. The position of the speaker on a particular list in relation to other speakers in the population were compared across lists with regard to his intelligibility scores. A combination of listener responses to each word on a given list resulted in the total list intelligibility score.

Results of this study showed that esophageal speakers and normal speakers were significantly different on all measures of intelligibility, with the esophageal population having significantly lower intelligibility scores than those of a normal population. The rank of the speakers did not change across lists and order of presentation. This suggests that even though an esophageal speaker has to modify his articulation, resonation, and phonation, the activity is fairly stable in terms of their effect on his intelligibility. (Tikofsky: 1965).

Comparison of Esophageal and Artificial Larynx Speakers

Shames, Font, and Matthews (1963) did some experimenting on the intelligibility of esophageal speech in a study relating variables to the learning of speech by laryngectomized patients. Results showed that although the artificial appliance groups had significantly faster reading time than the esophageal group, the esophageal group was superior on all other aspects of speech proficiency. Significantly higher mean articulation scores and word intelligibility scores were achieved by the esophageal group as well as significantly lower mean number of surd-sonant error. This refutes Hyman's (1955) findings that esophageal speakers and artificial appliance users are not significantly different in intelligibility (Shames: 1963).

Phonemic Errors Made by Listeners of Esophageal Speech

Nichols (1976a) developed a method to determine what patterns of phonemic errors listeners make when they hear the initial consonants and clusters of monosyllables spoken by esophageal speakers. From previous findings, Nichols felt that after esophageal speech has been used for a year or two, intelligibility of this speech will not improve anymore. To help with this, he used this study of confusions in recognizing phonemes spoken by esophageal speakers to develop multiple-choice intelligibility practice material for esophageal speakers.

Results showed that the most intelligible consonant was the /m/ with 69% correct and the least intelligible was the /p/ with 15% correct. The test of the consonant and clusters fell in the order from the most intelligible to the least intelligible: /f/, /d/, /s/, /sk/, /n/, /ʃ/, /t/, /dʒ/, /r/, /gr/, /l/, /st/, /tʃ/, /fl/, /g/, /br/, /kl/, /kr/. The mean intelligibility was 53% with a standard deviation of 13% and a standard error of the mean of 3% (Nichols: 1976).

Nichols (1976b) did another study of vowels and diphthongs using identical testing procedures. Results showed the most intelligible vowels was the /ei/ with 79% and the least intelligible was the /ju/ with 52%. The other vowels and diphthongs tested which ranged from the most intelligible to least intelligible were: /ɚ/, /o/, /i/, /I/, /æ/, /aɪ/, /ɔʊ/, /ə/, /u/, /ɛ/, /ɔɪ/, /ʊ/, /a/, /aʊ/. The mean intelligibility was 64% with a standard deviation of 8% and a standard error of the mean of 29%.

Auditory and Audiovisual Conditions

Lauder (1969) gives credit to Henry and Hyman (1968) for being among the first to conduct an experiment where intelligibility of esophageal speech was studied under auditory and audiovisual conditions. Subjects consisted of 12 good esophageal speakers. Each speaker was recorded on videotape as they read words from a multiple-choice intelligibility test. Thirty naive listeners evaluated both conditions,

auditory and audiovisual. At the one percent level of confidence, there was a significant difference between the means of the two conditions. In the audiovisual condition, the speakers were 11% more intelligible than in the auditory condition.

In summation, it has been shown that esophageal speech contains longer vowel duration, is affected in adverse noise condition and is less intelligible than normal speech. Also, listeners of esophageal speech find it difficult to understand the speaker. All of this, found out by use of auditory recordings of esophageal speech, points out the decreased intelligibility of laryngectomees who use esophageal speech.

More important to the present study was the finding that when esophageal speech was analyzed under auditory and audiovisual conditions, the latter condition was more intelligible when evaluated by listeners. Bearing this in mind, along with the decreased intelligibility of esophageal speech, this study dealt with finding out how much the addition of visual cues aids in the intelligibility of the speech. From this study, it will be shown whether or not the application of visual cues need to be implemented in the therapy for learning esophageal speech.

Chapter 2

METHOD

Speakers

Five esophageal speakers from the New Voice Club at the VA Medical Center in Asheville, N. C. provided the recorded material. All speakers had received therapy for learning esophageal speech.

Listeners

Listeners consisted of two groups of college students----twenty speech pathology majors and 20 non-speech pathology majors. Only those listeners who scored 90% or better on a sample screening of intelligibility of words spoken by the experimenter were used in the study.

Word Lists

Twenty-five phonetically balanced words were taken from CID Auditory Test W-22, PB-50 Word List 2. The PB-50 Word List was reduced to 25 words to limit the amount of time required for presentation of the word lists to the listeners. Also, words which contained troublesome phonemes for the speakers were eliminated. Four different orders of words were made from this list of twenty-five words to prevent the listener from learning the order

of the words presented. Two of the four word lists were recorded by each speaker.

Videotaping Conditions

A Sony Beta Max Portapak, model number SL0340 was used for recording purposes. A L-250 videocassette was used to record the speakers on.

The speaker was told to read the words presented to him on 5 x 8 index cards. The face, from the chin to the top of the head was shown on the screen for the audiovisual condition.

Experimental Conditions

The videotaping consisted of five esophageal speakers each reading from two phonetically balanced word lists (presented on the index cards). One word list was taped in the audiovisual condition and one word list was taped in the auditory condition. Specifically:

Subject	Condition	Word List
1	Audiovisual	1
1	Auditory	2
2	Auditory	3
2	Audiovisual	4
3	Audiovisual	2
3	Auditory	4
4	Auditory	1
4	Audiovisual	3
5	Audiovisual	2
5	Auditory	1

Each speaker practiced the two word lists he was given before actual videotaping began. An interval of five seconds followed each stimulus word in the auditory and audiovisual conditions which allowed the listeners time to record their responses. The carrier phrase

"number ____" was introduced before each word spoken by the speaker.

Before the esophageal speakers were presented on the screen, the experimenter appeared on the screen and read from one of the word lists to familiarize the listeners with the task and also for screening purposes previously mentioned.

The videotape was played to the listeners slightly above the normal threshold level. Listeners were seated approximately three feet from the screen. The tape was presented to only 5 listeners at a time to assure each listener could see the screen and hear the speakers at the same level.

The following instructions were presented to the listeners. 1. Non-speech pathology majors. "You are about to hear a group of word lists spoken by 5 men who have had their voice box removed. Each speaker will present two word lists. One time you will <u>see and hear</u> the speaker on the screen and the other time you will only <u>hear</u> the speaker. You will know which one to expect by looking on the Listener's Form beside the speaker number. When the speaker appears on the screen, look at him, listen, and then write down the word you think you hear beside the appropriate number on the Listener's Form sheet. It is very important to look before you write. When the word list is presented with sound only, write down the word you think you hear beside the appropriate number. If

at any time you do not understand a word at all, just leave the number blank. Do not go back and change your answers. For practice, I will appear on the screen first and read twenty-five words from a word list. Please write down the words I say beside the appropriate numbers under the word, 'SAMPLE'. Any questions?" 2. Speech Pathology majors. The same instructions will be given except the first sentence will read, "You are about to hear a group of word lists spoken by 5 esophageal speakers."

The Listener's Form consisted of the numbers 1-25 written beneath each speaker's number in both audiovisual and auditory conditions. Listeners recorded their responses there.

Chapter 3

RESULTS

The purpose of this study was to determine if the intelligibility of esophageal speech is improved by the addition of the visual component to the auditory component. Speech pathology majors and non-speech pathology majors were used to analyze the esophageal speech.

Scoring Procedures

Each response recorded on the Listener's Form sheet was scored correct or incorrect according to what the appropriate response was supposed to be as determined by the examiner. There was a possible score of one hundred correct responses for each of the twenty-five words from the word lists. A percentage of correct responses by the listeners was given to each word. From this the percentages were categorized into four conditions. The conditions were: 1. Speech pathology majors--Audiovisual 2. Speech pathology majors--Auditory 3. Non-speech pathology majors--Audiovisual 4. Non-speech pathology majors--Auditory. Tables 1 and 2 contain these scores.

Figure 1 shows the mean scores of speech pathology majors and non-speech pathology majors in analyzing words

Table 1

SCORES OF SPEECH PATHOLOGY MAJORS FOR WORDS IN THE AUDIOVISUAL CONDITION AND AUDITORY CONDITION

Words	Audiovisual	Auditory
cap	89	88
cars	97	96
chest	95	97
die	91	97
does	97	94
else	86	85
flat	98	96
gave	100	97
ice	94	96
jaw	76	83
key	91	86
live	98	97
may	96	91
new	87	80
odd	98	88
off	70	70
one	92	83
smart	92	94
star	90	83
tare	93	86
that	89	95
well	98	81
with	100	94
young	96	98
your	97	79

Table 2

SCORES OF NON-SPEECH PATHOLOGY MAJORS FOR WORDS IN THE AUDIOVISUAL CONDITION AND AUDITORY CONDITION

Words	Audiovisual	Auditory
cap	84	84
cars	90	90
chest	83	85
die	86	88
does	97	93
else	59	44
flat	97	92
gave	96	94
ice	84	82
jaw	67	83
key	75	77
live	90	87
may	97	90
new	83	80
odd	96	84
off	67	57
one	89	72
smart	93	94
star	88	75
tare	89	84
that	92	98
well	99	79
with	100	87
young	91	95
your	96	82

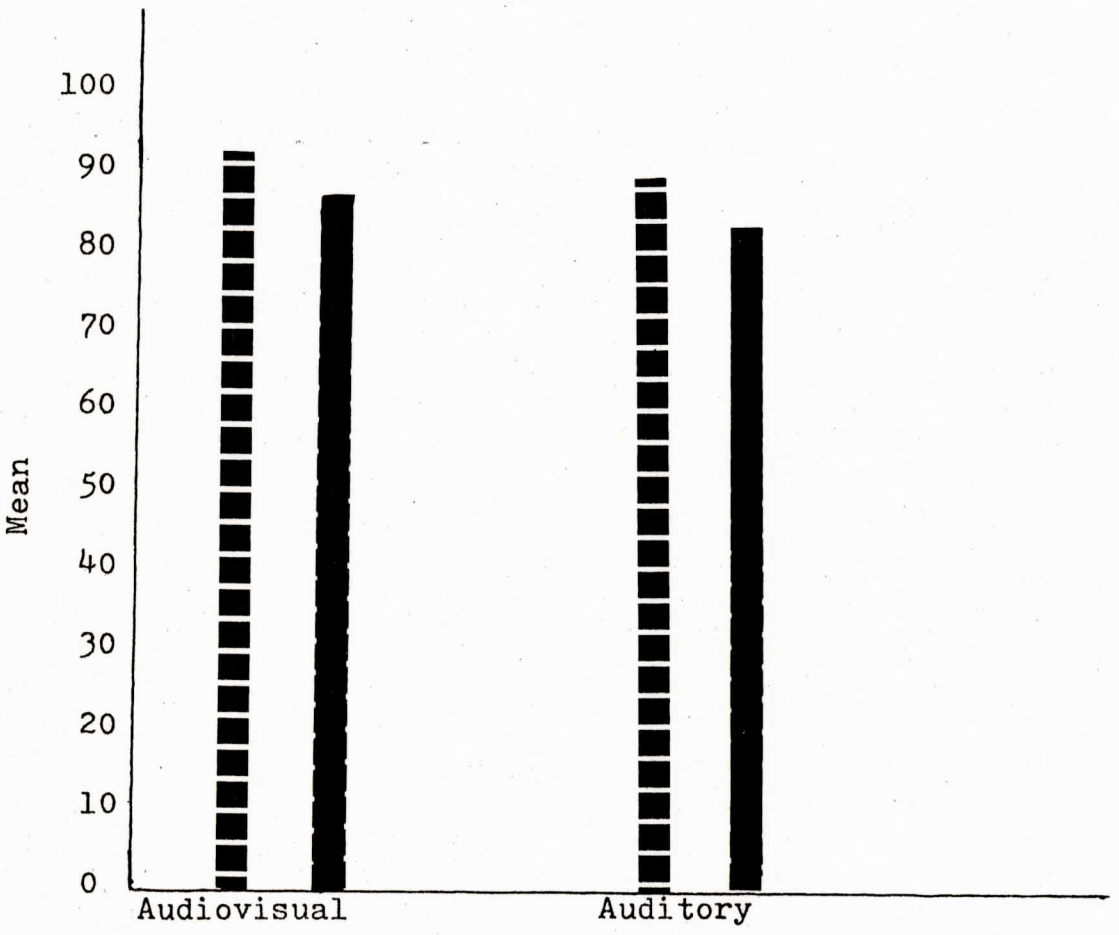

Figure 1

Mean Scores of Speech Pathology and Non-speech Pathology Majors in Analyzing Words in the Audiovisual and Auditory Components of Esophageal Speech

▮▮▮ - Speech Pathology Majors

▮▮▮ - Non-speech Pathology Majors

in the audiovisual and auditory components of esophageal speech. The mean score for speech pathology majors in analyzing words in the audiovisual component of esophageal speech was 92.4. In the auditory component, the mean score was 89.4.

The mean score for non-speech pathology majors in analyzing words in the audiovisual component of esophageal speech was 87.5. In the auditory component, the mean score was 83.

Figure 2 shows the range of scores of speech pathology majors and non-speech pathology majors in analyzing words in the audiovisual and auditory components of esophageal speech. The range of scores for speech pathology majors in analyzing words in the audiovisual component of esophageal speech was 30, from 70 to 100. In the auditory component, the range was 27, from 70 to 97.

The range of scores for non-speech pathology majors in analyzing words in the audiovisual component of esophageal speech was 41, from 59 to 100. In the auditory component, the range was 54, from 44 to 98.

Figure 3 shows the standard deviation of speech pathology majors and non-speech pathology majors in analyzing words in the audiovisual and auditory components of esophageal speech. The standard deviation for speech pathology majors in analyzing words in the audiovisual component of esophageal speech was 7.1. In the auditory component, the standard deviation was 7.5.

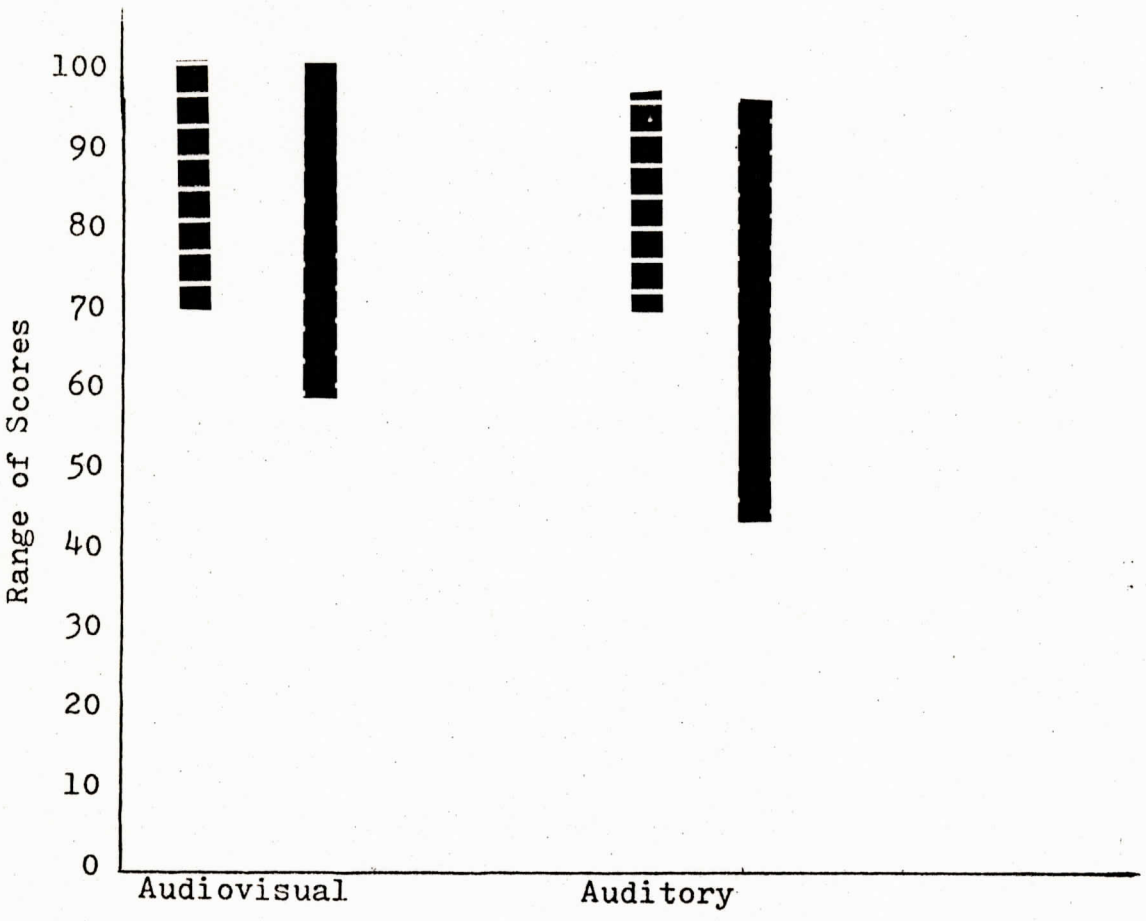

Figure 2

Range of Scores of Speech Pathology Majors and Non-speech Pathology Majors in Analyzing Words in the Audiovisual and Auditory Components of Esophageal Speech

▮▮▮ - Speech Pathology Majors

▮▮▮ - Non-speech Pathology Majors

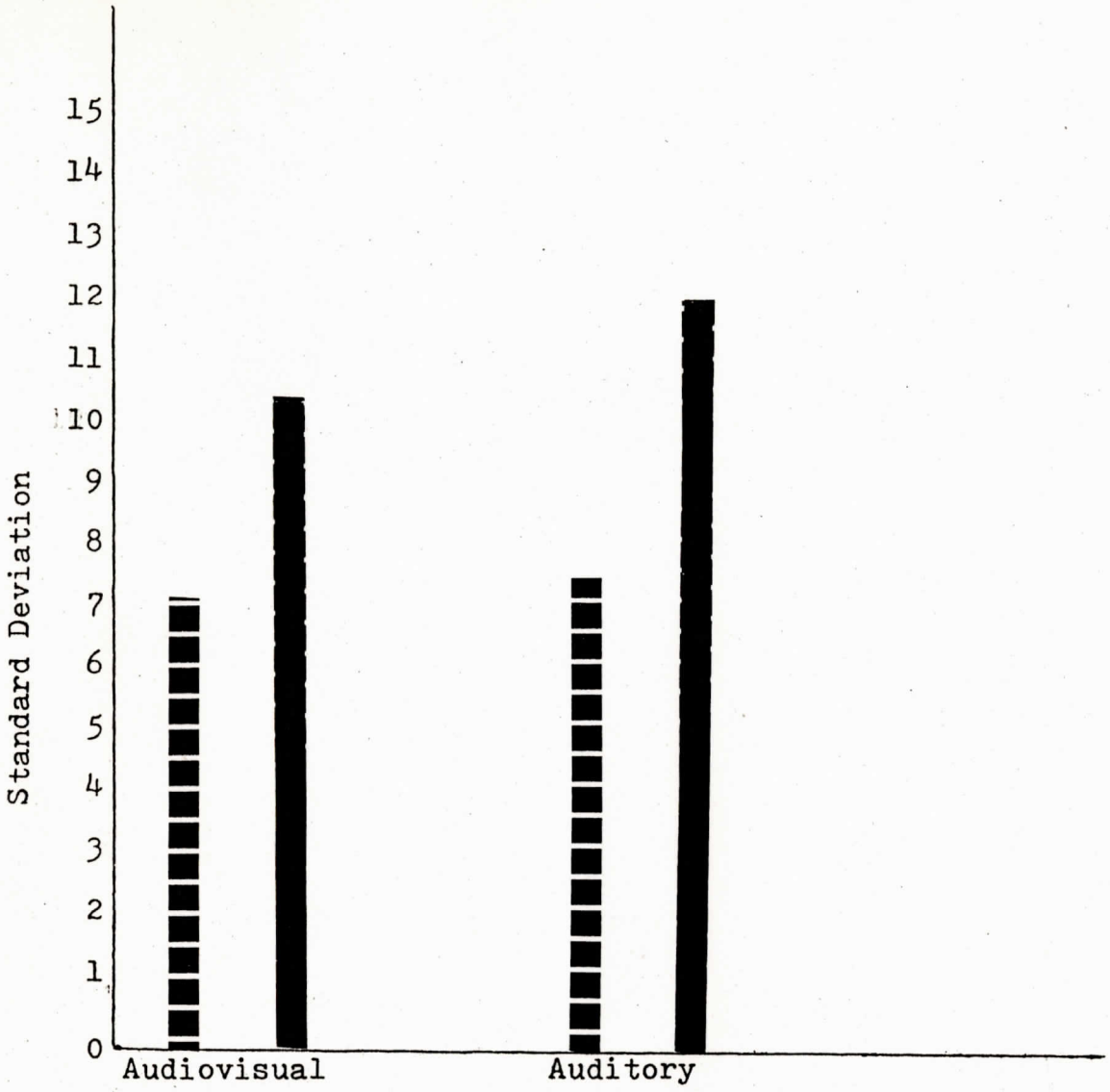

Figure 3

Standard Deviations of Speech Pathology and Non-speech Pathology Majors in Analyzing Words in the Audiovisual and Auditory Components of Esophageal Speech

▮▮▮ - Speech Pathology Majors

▮▮▮ - Non-speech Pathology Majors

The standard deviation for non-speech pathology majors in analyzing words in the audiovisual component of esophageal speech was 10.6. In the auditory component, the standard deviation was 11.8.

Analysis of the Data

The t-tests for determining differences between correlated and uncorrelated means were used in the analysis of the data and are discussed under the restatement of each null hypothesis.

Null Hypothesis 1

There is no significant difference between the scores in the audiovisual component and the auditory component of esophageal speech as analyzed by speech pathology majors.

Null hypothesis 1 was rejected at the .05 level of significance. Analysis of the data indicated that there was a significant difference between the scores in the audiovisual component and the auditory component of esophageal speech.

Null Hypothesis 2

There is no significant difference between the scores in the audiovisual component and the auditory component of esophageal speech as analyzed by non-speech pathology majors.

Null hypothesis 2 was rejected at the .05 level of significance. Analysis of the data indicated that there was a significant difference between the scores in the audiovisual component and the auditory component of esophageal speech.

Null Hypothesis 3

There is no significant difference between the scores of speech pathology majors and non-speech pathology majors in the analysis of words in the audiovisual component of esophageal speech.

Null hypothesis 3 was rejected at the .05 level of significance. Analysis of the data indicated that there was a significant difference between the scores of speech pathology majors and non-speech pathology majors in the audiovisual component.

Null Hypothesis 4

There is no significant difference between the scores of speech pathology majors and non-speech pathology majors in the analysis of words in the auditory component of esophageal speech.

Null hypothesis 4 was rejected at the .05 level of significance. Analysis of the data indicated that there was a significant difference between the scores of speech pathology majors and non-speech pathology majors in the auditory component.

Table 3

t RATIOS BETWEEN SCORES OF SPEECH PATHOLOGY MAJORS AND NON-SPEECH PATHOLOGY MAJORS IN THE AUDIOVISUAL COMPONENT AND THE AUDITORY COMPONENT OF ESOPHAGEAL SPEECH

Measure	df	t-ratio	level of significance
Audiovisual	48	2.06	.05
Auditory	48	2.27	.05

Table 4

t RATIOS BETWEEN THE AUDIOVISUAL COMPONENT AND THE AUDITORY COMPONENT OF ESOPHAGEAL SPEECH AS ANALYZED BY SPEECH PATHOLOGY MAJORS AND NON-SPEECH PATHOLOGY MAJORS

Measure	df	t-ratio	level of significance
Speech Pathology	48	2.2	.05
Non-Speech Pathology	48	2.69	.05

Chapter 4

SUMMARY

The purpose of this study was to determine if providing the listener with visual cues in responding to esophageal speech increased the intelligibility of the esophageal speech. A secondary objective was to determine whether there was a significant difference between the scores of speech pathology majors and non-speech pathology majors in analyzing esophageal speech.

Conclusions and Implications

Based on the statistical analysis of the data, the following conclusions were made:

1. There is a significant difference between the scores in the audiovisual and auditory components of esophageal speech as analyzed by speech pathology majors. The addition of the visual component of esophageal speech increases the intelligibility.

2. There is a significant difference between the scores in the audiovisual and auditory components of esophageal speech as analyzed by non-speech pathology majors. The addition of the visual component of esophageal speech increases the intelligibility of it.

3. There is a significant difference between the scores of speech pathology majors and non-speech pathology majors when analyzing the audiovisual component of esophageal speech.

Speech pathology majors exibit higher listening scores than non-speech pathology majors.

4. There is a significant difference between the scores of speech pathology majors and non-speech pathology majors when analyzing the auditory component of esophageal speech. Speech pathology majors exibit higher listening scores than non-speech pathology majors.

From these conclusions, it is justifiable that speech clinicians should emphasize the importance of visual cues in the learning of esophageal speech. Also it is assumed from these conclusions that because of the training speech pathology majors receive in recognition and analysis of phonemes, knowledge of voice disorders, and direct contact and therapy with speech disorders, their scores were higher than non-speech pathology majors. This implies that knowledge of these constituents aids in enhancing the intelligibility of esophageal speech. Family members of esophageal speakers may benefit from this knowledge and should receive therapy and training on the application of visual cues.

Limitations of the Study

The following limitations for this study were recognized:

1. The limited number of speakers may have reduced the validity of the study.
2. Speech pathology majors used as listeners were at different levels of study and competence in speech related areas.
3. Only use of words was used to determine intelligibility of esophageal speech as compared to nonsense words and/or sentences.

4. The speakers used were at different levels of esophageal speech competency.

Suggestions for Further Research

Further research in this area should include:

1. The use of sentences or nonsense words in the analysis of the intelligibility of esophageal speech under audiovisual and auditory conditions.

2. A comparison of the intelligibility of esophageal speakers who have received instruction on the application of visual cues in learning of esophageal speech and those who have not.

3. A study on how much visual cues aid in increasing the intelligibility of consonants, vowels, and diphthongs found to be the least intelligible as suggested in Nichol's (1976: a,b) study on phonemic errors made by listeners of esophageal speech.

4. A study to find out if therapy and training given to family members of esophageal speakers on the application of visual cues aids in increasing the intelligibility of the speech as compared to families who have not received therapy and training.

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APPENDIX A

WORD LISTS

List 1	List 2	List 3	List 4
1. smart	1. chest	1. young	1. off
2. well	2. your	2. that	2. flat
3. jaw	3. gave	3. with	3. tear (tare)
4. off	4. ice	4. key	4. jaw
5. cap	5. die (dye)	5. does	5. star
6. does	6. tear (tare)	6. cars	6. die (dye)
7. that	7. one (won)	7. else	7. one (won)
8. with	8. new (knew)	8. new (knew)	8. odd
9. live (verb)	9. live (verb)	9. cap	9. cap
10. one (won)	10. cars	10. one (won)	10. ice
11. die (dye)	11. with	11. star	11. else
12. gave	12. young	12. tear (tare)	12. may
13. chest	13. that	13. off (won)	13. cars
14. your	14. key	14. flat	14. gave
15. flat	15. does	15. jaw	15. does
16. ice	16. else	16. die	16. well
17. tear (tare)	17. cap	17. odd	17. key
18. new (knew)	18. star	18. ice	18. your
19. cars	19. off	19. may	19. with
20. young	20. jaw	20. gave	20. smart
21. key	21. odd	21. well	21. that
22. else	22. may	22. your	22. chest
23. star	23. well	23. smart	23. live (verb)
24. odd	24. smart	24. chest	24. young
25. may	25. flat	25. live (verb)	25. new (knew)