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An Investigation of the Effect of Auditory and Combined Auditory-Visual Cues Upon Judged Intelligibility of Artificial Larynx Speech and Esophageal Speech

Mary Ellen Carder
Western Michigan University

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AN INVESTIGATION OF THE EFFECT OF AUDITORY AND COMBINED
AUDITORY-VISUAL CUES UPON JUDGED INTELLIGIBILITY OF
ARTIFICIAL LARYNX SPEECH AND ESOPHAGEAL SPEECH

by

Mary Ellen Carder

A thesis presented to the
Faculty of the School of Graduate
Studies in partial fulfillment
of the
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CHAPTER I

THE BACKGROUND AND PURPOSE OF THE STUDY

Introduction

Surveys have shown that the incidence of total laryngectomy, surgical removal of the larynx, has increased steadily in the United States since 1947 when a total of 846 cases was reported (19, 20), to the present time when cancer registries indicate that about 4,400 new cases of cancer of the larynx are discovered annually (13). While it is estimated that in the United States at the present time there are 15,000 to 20,000 individuals who have undergone surgical removal of the larynx due to a carcinomatous condition of that organ (27), it is probable that the total population of laryngectomees would exceed this number if statistical information were available concerning the number of laryngectomies necessitated by accidents, injuries, or other pathological conditions which have been cited as additional causes for excision of the larynx (28).

This increase in the incidence of total laryngectomy and a concomitant increase in the survival rate of laryngectomized patients (13) appear to have given impetus to the awareness of and concern for the importance of the problems pertaining to the rehabilitation of these individuals. This impetus has been especially reflected in the literature of the medical profession and the field of speech pathology. Discussions concerning the rehabilitation of the laryngectomee have been
directed toward the medical aspects of the problem (10, 14, 25), the social, psychological, and economic readjustment of these individuals (21, 24, 26), and the importance of the acquisition of postlaryngectomy speech (5, 17, 21, 22, 27). A special emphasis has been placed upon this latter aspect of rehabilitation since "...loss of the power of speech is the basic and outstanding disability of total laryngectomy" (22, p. 823).

It is generally accepted that there are two basic methods of producing postlaryngectomy speech (21). One of these has been labeled esophageal speech and the second is referred to as artificial larynx speech.

Van Riper and Irwin (28, p. 176) describe esophageal speech in this manner:

Esophageal speech, like normal speech is based on a modulated air stream. The air supply has been swallowed into the stomach or, more usually trapped in the upper portion of the esophagus. The modulation or vibration seems in most cases to be due to the action of the cricopharyngeal sphincter.

More succinctly, Martin (21, p. 823) describes esophageal speech as "a deliberate and controlled belch, the sound of which is vocalized and articulated into speech by normal anatomical structures (tongue, teeth, lips, etc.)". In terms of these definitions it is apparent that an outstanding characteristic of esophageal speech production is the utilization of the anatomical structures of the speaker in both phonation and articulation.

On the other hand, artificial larynx speech may be described as
speech produced through the use of a mechanical or electrical sound source. In one case, the reed larynx, a vibrating reed generates a sound which is introduced through a tube directly into the oral cavity where it is articulated into speech. A second and more commonly used artificial larynx, however, is battery powered and introduces sound into the pharynx when the vibrating end of the cylindrical instrument is held against the skin of the neck. The sound is then modified by movements and positions of the articulatory structures (1).

Inasmuch as most laryngectomized individuals have the physiological potential for producing esophageal speech (14), these two basic methods of postlaryngectomy speech provide a choice and, therefore, often make necessary a decision regarding the method of speech to be utilized. In the past, the choice of method was determined by personal preference and previous experience of the physician or speech pathologist (11). More recently, a growing amount of attention has been directed toward the relative merits of artificial larynx speech and esophageal speech. Research directed toward the investigation of the acoustical aspects of esophageal and artificial larynx speech (3, 7, 12, 27) and listeners' reactions to speech produced by these methods (6, 11, 23, 26) has sought to provide a basis for a more objective approach to this problem.

Traditionally, however, among speech pathologists and members of the medical profession, there has been a preference for esophageal speech over speech produced by the artificial larynx method (21, 22, 23). In part this preference has been related to a consideration of the visual appeal of esophageal speech. An emphasis has been placed upon
the absence of a visible mechanical device as a major benefit of the esophageal method of postlaryngectomy speech, while one of the major objections to the artificial larynx method has been that it involves the use of an appliance that is conspicuous, cumbersome, embarrassing to the speaker, and distracting to the listener (2, 8, 17, 21).

Research regarding adverse social reaction to obvious physical deviations and cosmetic prostheses has been summarized by Wright (30), and has been discussed by Madan (18) and Fishman (9). Since the use of an artificial larynx emphasizes a disability or handicap and involves the apparent use of a mechanical device, it is possible to speculate that its use might engender somewhat similar social penalty. If this were found to be the case, this point would be of paramount importance in the consideration of the relative communicative value of esophageal speech and artificial larynx speech.

At the present time there is a dearth of information concerning social reaction to the visual aspects of postlaryngectomy speech. Two major questions are as yet unanswered: 1) What is the reaction of listeners to the visible use of a mechanical device in artificial larynx speech production? 2) Is this reaction such that it reduces the communicative effectiveness of artificial larynx speech in favor of esophageal speech production which is not dependent upon the use of an obvious mechanical or electric device?

Answers to these questions would have obvious clinical implications for the speech pathologist. If it were to be found that the use of a conspicuous mechanical device serves as a distraction that interferes
with the ability of listeners to understand, and, therefore, respond
in a positive manner to the laryngectomee in a communicative situation,
it would be advisable to consider this factor in the counseling of laryn­
gectomees. There would be value in the information in terms of l) moti­
vation toward the sometimes difficult task of learning esophageal speech,
or 2) the enhancement of the psychological adjustment of the artificial
larynx user who might find it necessary to cope with reduced communica­
tive effectiveness which might be confused with personal rejection.

On the other hand, if it were to be found that the use of an
artificial larynx does not serve as a distraction that interferes with
the listener's ability to communicate with the user, it would appear
that the specific choice of a method of postlaryngectomy speech for
each laryngectomized person should be made in terms of more practical
considerations than aesthetic values.

If the obvious use of an artificial larynx does engender adverse
social reactions, or is in anyway a factor of distraction in the com­
municative process, it was felt in the present study that this would
be reflected in a difference between listeners' reactions to the audi­
tory and the combined auditory-visual presentation of esophageal speech
and the auditory and the combined auditory-visual presentation of arti­
ficial larynx speech.

The Purpose of the Study

It was the purpose of this study to investigate the differential
effect of auditory and combined auditory-visual cues upon the judged
intelligibility\(^1\) of esophageal speech and artificial larynx speech.

\(^1\)In this study the term "intelligibility" was used synonymously with the term "understandability" and referred to the clarity of the speech being judged in terms of the listeners' comprehension.

Specifically, the investigation was directed toward answering the question: Is there a difference in the judged intelligibility of the same samples of esophageal speech or of artificial larynx speech under conditions of auditory and combined auditory-visual presentations?

It was proposed that by comparing the judged intelligibility ratings of postlaryngectomy speech as the speakers were only heard (tape recorded speech samples) with ratings based on the sound-film presentation of the same speakers, the influence of auditory and combined auditory-visual cues upon postlaryngectomy speech could be investigated.

It was further proposed that by comparing the two ratings of esophageal speech (auditory and combined auditory-visual) with the two ratings of artificial larynx speech, it would be possible to investigate any differential effect that might arise as a result of the mode of presentation.

The selection of intelligibility of speech as the criterion measure for the present study was dictated primarily by the necessity of using a dimension which could be meaningfully defined for naive listeners. It was recognized that intelligibility is but one of many variables which interact to determine communicative effectiveness. Because of
the interdependence of these variables, however, it was assumed that differences in listener reactions might be reflected in differences in judged intelligibility.

**Review of Related Research**

Research dealing with postlaryngectomy speech has been directed, to a large degree, toward the assessment of the acoustical or physical aspects of the two basic methods involved.

The scientific development of the artificial larynx has been reviewed by Barney (4) who has summarized experimental findings concerning certain acoustical characteristics of voice production through the use of a mechanical device. On the basis of extensive investigation, two major characteristics of the artificial larynx speech were reported: 1) a normal conversational loudness level can be attained with this instrument by most persons with a moderate amount of practice, and 2) the frequency spectra of artificial larynx speech essentially resemble those of normal speech.

In contrast to these acoustically desirable characteristics of speech produced by means of an artificial larynx, Barney (2) has also reported one major deficiency of speech produced by this method. This deficiency was described as inadequate sound production which resulted in a shortening of continuants and was related to the insufficient volume of the trapped air utilized by the speaker. Specifically, the /s/ and /sh/ were reportedly insufficient in volume and the /h/ sound was considered to be completely omitted.

A study of time and rate in esophageal speech has been reported
by Snidecor (27) who found that the time and rate performance level of superior esophageal speakers was above that necessary for satisfactory speech. Subjects for this project were six esophageal speakers who performed at the highest level of esophageal speech proficiency. Each speaker was rated in terms of the number of words and syllables spoken per charge of swallowed air, amount of time necessary to swallow a charge of air, and the number of words spoken per minute relative to normal speech. The emphasis in this study was upon the superior esophageal speaker, and the major purpose was to define the maximal expectation level of performance for esophageal speakers in an effort to establish boundaries and goals for the therapy process.

Esophageal speech has also been assessed experimentally with regard to fundamental frequency measurement and pitch perception (7). Results of this study, which utilized the superior esophageal speakers of the previously reviewed time and rate study and six superior normal speakers, demonstrated the mean fundamental frequency level for most esophageal speakers to be approximately one full octave below that of normal adult male speakers. While the effective range for five of the six subjects under study were found to be greater than an octave, and while the mean total frequency range for esophageal speech was found to be wider than that of the normal speakers, the esophageal speakers were judged to have a restricted pitch range when taped samples of the speech were perceptually evaluated. This limitation of perceived pitch range was explained as an artifact of the particular tones involved in the ranges of the two groups.
In another study of the acoustical properties of postlaryngectomy speech, Lafon (12) compared the speech of normal speakers and laryngectomized speakers using esophageal speech and artificial larynx speech. Sonagrams of certain vowel and short sentence productions were analyzed and compared. As a result of this study, Lafon reported that esophageal speech was found to be very similar to normal speech.

Research concerned with postlaryngectomy speech has also considered the comparison of artificial larynx speech and esophageal speech in terms of listeners' reactions to auditory presentations of speech samples.

One of the most prominent of these studies was one conducted by Hyman (11). This extensive study of esophageal speech, artificial larynx speech, and normal speech included an investigation of specific physical measurements of the three types of speech, a comparative evaluation of the intelligibility of artificial larynx speech and esophageal speech, and observations concerning which method of postlaryngectomy speech was "preferred" by listeners. In this study, which utilized tape recorded samples of speech, speakers using artificial larynges were found to be superior to esophageal speakers in reference to loudness, but no appreciable differences were found in terms of intelligibility between "good speakers of each group". However, in discussing which of the types of speech was "preferred" by listeners, Hyman reported that the voices of the artificial larynx speakers appeared to be found more pleasant than the voices of the esophageal speakers. Hyman concluded that, acoustically, speech produced by means of an artificial larynx was preferred over speech produced by the esophageal method.
Listener reaction to artificial larynx speech and esophageal speech has also been investigated by Shames, Font, and Matthews (26), who studied the relationships between specific measures of speech proficiency of 153 laryngectomized patients and a number of variables including biographical, social, medical, personality, and speech training. Findings resulting from the research efforts pertaining to the investigation of speech proficiency demonstrated, through the comparison of tape recorded speech samples, the superiority of esophageal speech over artificial larynx speech in terms of articulation, phonation, and word intelligibility.

In another study directed toward the investigation of the relative merits of esophageal speech and artificial larynx speech in terms of listener reaction, McCroskey and Mulligan (23) considered the relative intelligibility of the two methods as judged by sophisticated and naive listeners. Experienced speech therapists, graduate students in speech pathology, and naive listeners comprised three panels of ten listeners each who judged tape recorded samples of ten laryngectomized speakers reading different multiple-choice intelligibility word lists. Speech therapists and graduate students judged esophageal speech to be superior in intelligibility to artificial larynx speech, while, conversely, artificial larynx speech was judged to be more intelligible than esophageal speech by the panel of naive listeners. In a discussion of the contradictory intelligibility scores, it was suggested by the researchers that professional preferences or training may have had an influence upon the judgments made by the sophisticated listeners. It was concluded that the results
of the study indicated a strong tendency for artificial larynx speech to be considered more intelligible than esophageal when judgments are made by persons not previously exposed to either method of postlaryngectomy speech.

A final study to be reported in the review of research dealing with postlaryngectomy speech is an unpublished study by Crouse (6), which demonstrated a "preference" for esophageal speech over artificial larynx speech when judged by both sophisticated and naive listeners. Unlike the previous studies which have been reviewed, Crouse utilized both auditory and combined auditory-visual presentations of laryngectomized speakers. Reportedly, esophageal speech was preferred in each condition tested with a stronger preference for esophageal speech being expressed when judgments were based on the combined auditory-visual presentation of the speakers.

Summary and Limitations of Related Studies

The research which has been reviewed concerning postlaryngectomy speech has indicated the individual acoustical strengths of each of the two methods considered in the present study, and has provided an over-view of past research concerning the relative merits of the two methods. Individually, each method has been shown to offer a substitute voice that is acoustically adequate to meet the communicative needs of the average speaker. However, attempts to compare the two methods on the basis of listener re-
action to speech produced by these methods have resulted in contra-
dictory findings as to which method, if either, is superior to the
other.

With a single exception, all previous studies have demonstrated
the superiority of esophageal speech over artificial larynx speech
when "preference" was the criterion measure utilized by naive listen-
ers. However, the superiority of esophageal speech has not been
consistently substantiated when naive listeners have been asked to
judge the "intelligibility" of esophageal speech and artificial
larynx speech. These contradictory findings of past research indi-
cate a need for further experimental investigation of the relative
merits of the two primary methods of postlaryngectomy speech.

Beyond this is the consideration that past research has been
primarily concerned with the comparison of only the auditory as-
pects of esophageal speech and artificial larynx speech; the major-
ity of the studies have utilized only tape recorded samples of
postlaryngectomy speech. This has left relatively unexplored the
visual aspects of postlaryngectomy speech. This void in past
research leaves unanswered the questions concerning the major ob-
jection to artificial larynx speech: Does the listener find the
obvious use of an appliance objectionable, and, if so, does this
reaction reduce the communicative effectiveness of artificial
larynx speech in favor of esophageal speech in a face-to-face
situation?

In the single study which has considered the visual aspects of
postlaryngectomy speech, there appeared to be no adverse reaction to the use of an appliance in terms of a difference in the responses of the listeners to recorded and filmed presentations of the same samples of artificial larynx speech. Under each condition tested, esophageal speech was found to be superior to artificial larynx speech. However, the tendency for esophageal speech to be more strongly preferred over artificial larynx speech when the two types of speech were compared under combined auditory-visual presentation than when compared under only auditory (tape recorded) presentation suggested a need for further study of the influence of auditory and combined auditory-visual cues upon postlaryngectomy speech.

Statement of the Problem

The primary purpose of this study was to investigate the differential effects of auditory and combined auditory-visual cues upon the judged intelligibility of esophageal speech and artificial larynx speech. Specifically, the following questions were asked:

1. Is there a difference in the judged intelligibility of the same samples of esophageal speech under conditions of auditory and combined auditory-visual presentations?
2. Is there a difference in the judged intelligibility of the same samples of artificial larynx speech under conditions of auditory and combined auditory-visual presentations?
3. Do auditory cues and combined auditory-visual cues
differentially affect the judged intelligibility of esophageal speech and the judged intelligibility of artificial larynx speech?
CHAPTER II

THE SUBJECTS AND PROCEDURES OF THE STUDY

The purpose of this chapter is to describe: 1) the subjects who participated in the study, 2) the stimulus material that was utilized, 3) the equipment and the filming and recording procedures employed, 4) the judges and judging procedures, 5) the treatment of the data.

The Subjects

The subjects who participated in this study were seven male esophageal speakers and seven male artificial larynx speakers. All of the esophageal speakers and four of the artificial larynx speakers were members of the Anamilo Club of Detroit, a chapter of the International Association of Laryngectomees, and volunteered their participation in the study through that organization. The remaining three artificial larynx speakers were residents of southwestern Michigan and were located individually by the investigator. In each case the speech of the participant was judged by both the speaker and the investigator to be average or above in communicative effectiveness. In other words, the speech utilized by each speaker was adequately serving his daily communicative needs. While individually the speakers in this study represented a wide range of speech proficiency, it was the opinion of the investigator that, as a group, the speakers who utilized esophageal
speech were superior in speech proficiency to the speakers who employed the artificial larynx method of speech production. However, this was not considered to be an important factor since it was not the purpose of this study to actually compare the two methods of speech.

Of the seven artificial larynx speakers, four used the Aurex Electro-Larynx, two employed the Western Electric (Bell Telephone) Transistorized Electronic Larynx, and one speaker utilized an older model Western Electric battery powered artificial larynx.

The age range for the esophageal speakers was 34 years to 78 years with a mean age of 56. For the artificial larynx group, the ages ranged from 53 years to 87 years with a mean age of 67.

No attempt was made to control the two groups in terms of age, occupation, or educational attainment.

The Stimulus Material

The stimulus material in this investigation consisted of simultaneously filmed and tape recorded speech samples of seven esophageal speakers and seven artificial larynx speakers. Each speaker read a fifty-five word passage of continuous discourse. With the exception of the semi-vowel /hw/, each of the vowel sounds and each of the consonant sounds utilized in General American speech appeared at least once in the passage which read as follows:

Many people are taking a trip to the New York World's Fair this year. Everybody should go up to the fair if they have the chance. Right now, my plans are to go for just a few days. My family and I are looking forward to the trip with pleasure; we talk about it often.
Speaking time for the individual esophageal speakers varied from 18 seconds to 28 seconds with a mean for the group of 21.2 seconds. The time range for the artificial larynx speakers was 13 seconds to 21 seconds with a group mean of 18.4 seconds.

Filming and Recording Procedures and Equipment

While it was necessary to film and record the subjects of this study in six different locations, procedures and equipment were held as constant as possible in each situation.

Of the fourteen subjects participating in the study, nine of them were filmed and tape recorded in a conference room at the headquarters of the Michigan Cancer Foundation, Inc., in Detroit, Michigan; three subjects were filmed and recorded in their respective homes; while one subject was filmed in the laboratory at the Western Michigan University Speech Clinic and one at the Veterans' Facility, Grand Rapids, Michigan. None of these situations provided a room that was acoustically treated, but in each situation the room used was judged to be appropriately low in noise level and satisfactorily free of ambient sounds.

Each speech sample was recorded on a Voice of Music portable tape recorder (Model 730, Tape-O-Matic), using a crystal microphone which was placed on a table of standard height directly in front of each speaker. Twelve of the speakers were standing during the recordings. This placed the microphone approximately nine inches in front of the speaker at lower than waist level. In the case of two speakers who were seated during the recording periods due to the physical limitations of the
room in terms of lighting arrangements for filming, the same relative
distance from microphone to speaker was maintained. In the case of the
esophageal speakers, the microphone placement did not appear to intro­
duce any disadvantageous stoma blast effects. Each speaker was recorded
at a speed of 7.5 inches per second at a loudness level that was judged
to be adequate to provide clear and undistorted recordings.

The simultaneous filming of a full face and throat view of each
speaker was filmed at a speed of 24 frames per second with a Fairchild
Cinephonic Double Eight Millimeter sound camera, employing an Elgert
telephoto thirty-eight millimeter lens.

Prior to being recorded and filmed, each speaker was given a
5 X 7 card on which the fifty-five word reading passage had been typed.
The following directions were given by the experimenter:

This is a copy of what you will be reading when
you are in front of the camera. Please read it
over several times so it will be familiar to you.
Take as much practice time as you need to feel
comfortable reading the paragraph. You may read
it silently or aloud, or both.

When the subject indicated he was ready to be filmed, he was asked
to take his place before the camera.

Final directions to each speaker were:

Just read the paragraph in a comfortable and
natural manner. Read it as if you were talking
to a friend.

A 20 X 30 cue card was placed in the direct view of the speaker
during the filming and recording period. The reading passage, which
had been printed on the card in large black letters, was clearly visible
to each speaker. The ability of each speaker to easily see the cue card
was checked before each filming and an adjustment was made in the location of the card if this were necessary. In the case of gross misreadings or errors that made the speaker feel dissatisfied with his performance, the filming and recording were repeated.

Judges and Judging Procedures

Judges for this experiment were 38 graduate students at Western Michigan University currently enrolled in a Philosophy of Guidance course in the School of Education. The group ranged in age from 21 to 49 years, and was comprised of 21 males and 17 females. According to information volunteered by each student prior to participation in the study, no member of this group had a hearing loss, nor had any member had previous experience with postlaryngectomy speech. Though a larger number of students actually participated in the judging sessions, some of them were eliminated because of reported hearing loss, or prior experience with postlaryngectomy speech.

Stimulus material, which consisted of simultaneously tape recorded and filmed samples of postlaryngectomy speech, were presented to the judges on two consecutive days. Seven samples of artificial larynx speech and seven samples of esophageal speech were presented. Each sample was presented twice during each judging session, once by tape and once by sound film. Though the speakers were presented in groups with respect to type of speech and mode of presentation, the individual speakers were presented in a randomized order within each group. In other words, the order of appearance of the individual speakers differed between the
film and tape presentations.

The judging sessions were held in a large classroom. All auditory stimuli were presented free-field at a loudness level adequate for easy audition at all points in the room. The films were projected to a screen in the front and center of the room and were readily visible to all of the judges. Equipment utilized included a portable Voice of Music tape recorder (Model 730, Tape-O-Matic) and a Kodak eight millimeter sound-film projector (Model 1).

It was the task of the judges to rate each speaker in terms of intelligibility, or understandability of speech. Since the same passage of speech was utilized by each speaker, the judges were given an opportunity to become familiar with the words of the passage by reading the passage several times before the stimulus materials were presented. This was deemed necessary to counteract any practice effect, and, therefore, a high rating of judged intelligibility that might occur with the repeated presentation of the passage during the judging situations.

Detailed instructions concerning the methods of judging and rating were given by the investigator at the beginning of each of the two judging sessions. A copy of these instructions and of the rating sheets that were employed have been included in Appendix A.

For the purpose of this study, the judges were asked to rate each speaker in terms of intelligibility on a seven point equal-appearing intervals scale with one representing the lowest degree of intelligibility and seven representing the highest degree of intelligibility. This method
of psychological scaling has been utilized extensively in speech path­ology research, and was considered to be an appropriate and useful pro­cedure for obtaining criterion measurers of intelligibility.

During the instructions to the judges, speech samples representing the extreme ends of the rating scale were presented for each type of speech under investigation. With the exception of one sample of esoph­ageal speech, these samples were selected from the speech samples heard during the judging sessions.

The order of presentation of the stimulus material for the first judging session was: Condition I, tape recorded esophageal speech; Condition II, filmed artificial larynx speech; Condition III, filmed esophageal speech; Condition IV, tape recorded artificial larynx speech.

This order was reversed during the second session and was as follows: Condition IV, Condition III, Condition II, and Condition I.

Approximately six seconds of blank tape or film followed the pre­sentation of each speaker and provided the judges time to record their responses on the rating sheets. The time period of each judging ses­sion was approximately forty-five minutes.

The Treatment of the Data

A Lindquist Type I analysis of variance (16, p. 267) was utilized to determine the significance of the differences among the group means of each mode of presentation under investigation in this study. This design was chosen because it permits an elimination of inter-subject differences and because it makes possible an analysis of any inter­action observed between type of speech and mode of presentation. A
complete discussion of the treatment of the data will be presented in
Chapter III.
CHAPTER III

THE RESULTS AND DISCUSSION OF THE STUDY

Individual mean ratings of judged intelligibility were computed for each speaker for each of the two judging sessions for each condition tested, auditory and combined auditory-visual. These individual mean ratings and the group mean ratings are presented in Appendix B.

Mean intelligibility ratings of esophageal speakers ranged from 1.89 to 6.76 during the first judging session. Mean ratings based on the tape recorded samples of speech ranged from 1.89 to 6.76; those based on the filmed samples ranged from 3.26 to 6.18. During the second judging session the mean ratings based on the tape recorded presentations of speech samples ranged from 3.24 to 6.92, while the mean ratings based on the filmed presentations ranged from 3.26 to 6.76.

The mean intelligibility ratings of the artificial larynx users during the first judging session ranged from 1.13 to 6.21 for the ratings based on the tape recorded samples of speech, and from 1.03 to 5.45 for those based on the filmed presentations. During the second judging session, the mean ratings for this group of speakers ranged from 1.00 to 6.08 for the tape recorded speech samples and from 1.00 to 6.58 for the filmed presentation of the same samples of speech.

The wide range of individual mean ratings is indicative of the
individual differences of speech proficiency that existed among the subjects of the study. Although high ratings were consistently given some individual speakers regardless of the method of speech employed, it is apparent from the group means (see Appendix B) that, as a group, the esophageal speakers were consistently rated higher than the artificial larynx users regardless of the mode of presentation. These individual differences and group differences have already been discussed and, as was stated previously, were not considered to be detrimental to the purpose of this study.

Pearson product-moment correlation coefficients were computed between the mean ratings of judged intelligibility of each speaker obtained in the two judging sessions for each of the two conditions. For the esophageal speakers, a correlation of .98 was obtained between the judgments based on the tape recorded speech samples for the two judging sessions and a correlation of .82 was obtained on the judgments of the filmed presentations for both sessions. For the artificial larynx speakers, a correlation of .99 was obtained between the two judgments based on the tape recorded speech samples and a correlation of .97 was obtained for the judged intelligibility ratings based on the filmed presentations of the speakers for both sessions. The obtained correlation coefficients indicated that the naive judges who participated in this study were highly consistent in judging the relative intelligibility of the individual speakers for both judging sessions. Although the mean ratings for the majority of the speakers generally were somewhat higher during the second judging session, relative to each other, the individual speakers
were rated similarly in both sessions.

Results of the First Judging Session

Group means for each type of speech for each mode of presentation were computed and reported separately for each judging session. The group mean ratings of judged intelligibility for the first session are presented in Table I.

<table>
<thead>
<tr>
<th>Speakers</th>
<th>Auditory</th>
<th>Auditory-Visual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artificial Larynx</td>
<td>3.29</td>
<td>3.02</td>
</tr>
<tr>
<td>Esophageal</td>
<td>4.01</td>
<td>4.37</td>
</tr>
</tbody>
</table>

The significance of the differences among these means was tested through the use of a Lindquist Type I analysis of variance (16, p. 267).

As indicated by the analysis summary, neither the differences between the main effects of mode of presentation nor the differences between types of speech were statistically significant in the first judging session. However, a significant interaction between mode of presentation and type of speech indicated that judged intelligibility varied differently within the two groups of speakers as a function of mode of presentation. With reference to Figure 1 it may be seen
<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sums of Squares</th>
<th>Mean Squares</th>
<th>F*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>13</td>
<td>77.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Types of Speech (B)</td>
<td>1</td>
<td>7.59</td>
<td>7.59</td>
<td>1.30**</td>
</tr>
<tr>
<td>Error (b)</td>
<td>12</td>
<td>70.14</td>
<td>5.85</td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td>14</td>
<td>2.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mode of Presentation (A)</td>
<td>1</td>
<td>.02</td>
<td>.02</td>
<td>.17***</td>
</tr>
<tr>
<td>AB (Interaction)</td>
<td>1</td>
<td>.69</td>
<td>.69</td>
<td>5.75****</td>
</tr>
<tr>
<td>Error (w)</td>
<td>12</td>
<td>1.41</td>
<td>.12</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>27</td>
<td>79.85</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*F_05(df = 12) = 4.75
**ms_B / ms error (b)
***ms_A / ms error (w)
****ms_AB / ms error (w)
that in the case of esophageal speech, the judges had rated the speech higher in intelligibility during the filmed presentation of the speakers than during the presentation of the tape recorded samples of speech. Conversely, in the case of artificial larynx speech, the judged intelligibility of the speech samples was higher when the speech was presented auditorily as opposed to the combined auditory-visual presentation. A test of the simple effects of mode of presentation utilizing a t-test with \( ms(w) \) as the error term was employed to determine the effect of mode of presentation within each group of speakers considered separately. The main effects were confounded by the significant interaction; hence, it was necessary to test the simple effects in order to look at differences within each group (type of speech). Significant differences (\( t = 2.16 \)) were found in the case of both artificial larynx speech (\( t = 2.29 \)) and esophageal speech (\( t = 3.13 \)), indicating that the judged intelligibility of the same samples of esophageal speech and of artificial larynx speech were not the same under auditory and combined auditory-visual presentation.

In direction, the inverse relationship of the judged intelligibility ratings of the two types of speech suggested that the judges found the combined auditory-visual presentation an enhancement to the intelligibility and understandability of esophageal speech, while there was an indication that seeing as well as hearing the artificial larynx speakers had a detrimental effect upon the judged intelligibility of this type of postlaryngectomy speech.

Mean judged intelligibility group ratings were higher for esoph-
Figure 1. Judged intelligibility of esophageal speech and artificial larynx speech under two modes of presentation during judging session I.
ageal speech when judgments were based on combined auditory-visual cues than when judgments were based on auditory cues alone. With reference to artificial larynx speech, however, the converse was true. Judgments of intelligibility of artificial larynx speech were higher when based on auditory cues than when based on combined auditory-visual cues. It was indicated, then, on the basis of the results of the first judging session that auditory cues and combined auditory-visual cues differentially affected the judged intelligibility of these two types of postlaryngectomy speech.

Results of the Second Judging Session

The group mean ratings of the judged intelligibility of esophageal speech and artificial larynx speech related to both modes of presentation were computed and are presented in Table III.

<table>
<thead>
<tr>
<th>Speakers</th>
<th>Auditory</th>
<th>Auditory-Visual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artificial Larynx</td>
<td>3.44</td>
<td>3.68</td>
</tr>
<tr>
<td>Esophageal</td>
<td>4.94</td>
<td>4.63</td>
</tr>
</tbody>
</table>

As with the data of the first judging session, a Lindquist Type I analysis of variance was used to analyze the data of the second session. A summary of the analysis is presented in Table IV.
<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sums of Squares</th>
<th>Mean Squares</th>
<th>F*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>13</td>
<td>88.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Types of Speech (B)</td>
<td>1</td>
<td>10.30</td>
<td>10.30</td>
<td>1.58**</td>
</tr>
<tr>
<td>Error (b)</td>
<td>12</td>
<td>77.99</td>
<td>6.50</td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td>14</td>
<td>2.28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mode of Presentation (A)</td>
<td>1</td>
<td>.01</td>
<td>.01</td>
<td>.07***</td>
</tr>
<tr>
<td>AB (Interaction)</td>
<td>1</td>
<td>.58</td>
<td>.58</td>
<td>4.14****</td>
</tr>
<tr>
<td>Error (w)</td>
<td>12</td>
<td>1.69</td>
<td>.14</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>27</td>
<td>90.56</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ F_{0.05}(df = 12) = 4.75 \]

\[ **m/s_{B}/m/s \text{ error (b)} \]

\[ ***m/s_{A}/m/s \text{ error (w)} \]

\[ ****m/s_{AB}/m/s \text{ error (w)} \]
As indicated by the results presented in Table IV, none of the differences obtained during the second judging session were sufficiently great to satisfy the established .05 level of significance. The differences between the judged intelligibility obtained with the two modes of presentation were not significant. This had also been the case during the first judging session.

However, changes had occurred in relation to the AB interaction effect that had been apparent during the first judging session: 1) the interaction effect was reduced to a nonsignificant level, 2) the magnitude of the differences between modes of presentation relative to each type of speech was reduced and non-significant, and 3) the direction of these differences, as shown in Figure 2, were reversed when compared with the differences which occurred during the first judging session.

Comparison of the combined data from the two judging sessions indicates the presence of a trend for each type of speech under investigation to become more intelligible to the listener with repeated exposure. While it is true that consideration must be given the possibility that this trend simply reflects an increased familiarity of the judges with the reading passage utilized by the speakers, an effect of this nature was not apparent in the individual ratings of speakers within each group (from first speaker to last), nor was it great enough to elevate the ratings of the artificial larynx speakers in relation to the esophageal speakers during the second judging session. On the other hand, the possibility that this trend is related to an order effect is strongly suggested in the results of
Figure 2. Judged intelligibility of esophageal speech and artificial larynx speech under two modes of presentation during judging session II.
both judging sessions. This has already been discussed in terms of the higher ratings given the second presentation of each type of speech in the individual judging sessions, but it is also reflected in generally higher mean ratings of judged intelligibility for both types of speech, regardless of mode of presentation, during the second judging session. This trend is graphically presented in Figures 3 and 4.

Discussion

An analysis of the results of the first judging session in this investigation suggested the existence of a differential effect of auditory and combined auditory-visual cues upon the judged intelligibility of the two types of speech under investigation. A differential effect, although not significant, was also suggested in the results of the second judging session. However, the directions of these effects were reversed during the second judging session when the order of the presentation of stimuli was changed. The differences between the first and second sessions suggested a need to re-evaluate the results of both judging sessions.

In re-evaluating the findings of the first judging session, it became necessary to consider the possibility that the results of that session might have been, at least in part, a function of an order effect. Within each group of speakers, judged intelligibility ratings had been higher during the second presentation of the same speech samples regardless of mode of presentation.

The filmed samples of esophageal speech, which had been presented
Figure 3. Mean intelligibility ratings of artificial larynx speech for judging sessions I and II.
Figure 4. Mean intelligibility ratings of esophageal speech for judging sessions I and II.
after the tape recorded presentation of the same speech samples, had been rated higher than the taped samples. On the other hand, the tape recorded samples of artificial larynx speech had been presented after the filmed samples of artificial larynx speech, and had been rated higher than the filmed presentations of the same speech samples.

In the results of the second judging session, when the order of mode of presentation was reversed, the same pattern of increased intelligibility ratings occurred with the second exposure to each type of speech. This resulted, however, in the judged intelligibility ratings of the filmed presentation of the artificial larynx speech samples being higher than the tape recorded presentation of the same samples of speech. Conversely, in the case of esophageal speech, the taped speech samples were rated higher than the filmed presentation of the speech samples.

The order of the modes of presentation of the stimuli and the ascending nature of the ratings of judged intelligibility from Condition I to Condition IV for the two judging sessions are presented in Figure 5 which combines the data from Figures 1 and 2. Attention is directed to the ratings of each type of speech in relation to the order of the modes of presentation.

Because of the differences in criterion measures and purposes, direct comparisons cannot be made between this study and the single other study of postlaryngectomy speech which investigated listener reaction to both auditory and combined auditory-visual presentation of stimuli. However, there are certain questions which arise when the
Figure 5. Judged intelligibility of esophageal speech and artificial larynx speech under two modes of presentation during judging sessions I and II. (Numbers in parentheses indicate order of presentation.)
results of these two studies are reviewed.

Crouse (6) reported that her listeners indicated a preference for esophageal speech over artificial larynx speech under combined auditory-visual observations which was stronger than their preference based on auditory observations alone. An inference that may be made on the basis of this is that some differential effect related to the mode of presentation was operating to establish this trend, even though esophageal speech was also preferred during the auditory presentation of the stimuli. Though the statistical treatment of Crouse's data did not provide the opportunity to make a judgment concerning the significance of this differential effect, the trend is apparent. This trend is the same that was found to exist with respect to intelligibility ratings obtained during the first judging session of the present study. However, the reversal of this trend during the second judging session suggested that factors other than mode of presentation may have operated to establish the observed trends.
CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

It must be concluded that on the basis of the present study there is a lack of convincing evidence that visual cues importantly and consistently affect judgments of intelligibility of post-laryngectomy speech. It would appear that the intelligibility of postlaryngectomy speech is determined primarily by the listeners' reaction to auditory cues.

While the results of the present study suggest that auditory and combined auditory-visual cues may differentially affect the judged intelligibility of esophageal speech and artificial larynx speech during the first exposure to these types of speech, it is also suggested that with continued exposure, this differential effect may be minimized or eliminated in favor of an acceptance of this type of speech in terms of judged intelligibility. This acceptance, or adaptation, may be independent of the type of postlaryngectomy speech employed or of visual cues.

On the basis of this, it may be hypothesized that the utilization of artificial larynx speech that is average or above in proficiency is to be preferred over poor esophageal speech. This has strong implications for the speech pathologist who often spends countless therapy hours in helping a client to develop only poor or inferior esophageal speech. It is possible that it would be more advantageous
to utilize this time in helping the client to develop highly skillful use of an artificial larynx.

With specific reference to the visual aspects of artificial larynx speech, it must be concluded that from the results of this study there is no evidence that the obvious use of a mechanical device reduces the communicative effectiveness of speech produced by this method, insofar as this reduction can be measured in terms of the effects of auditory and combined auditory-visual cues upon judged intelligibility. However, in the present study, a trend in this direction was suggested with the first exposure of the judges to artificial larynx speech. Although it is possible that this trend was due, at least in part, to an order effect, a need for further investigation of possible adverse social reactions to the obvious use of the artificial larynx is indicated. Questions concerning this major objection to the artificial larynx method of postlaryngectomy speech are still unanswered.

Therefore, a need for carefully controlled investigations concerning the visual aspects of postlaryngectomy speech still exists. It is recommended that with the elimination of certain limitations of the present study, future investigations similar to this study would have value. The major limitations of the present study were the utilization of only one group of judges and only two judging sessions. By utilizing a larger number of groups of naive judges, it would be possible to investigate thoroughly the first reactions of listeners to postlaryngectomy speech and the influence continued
exposure to this type of speech has upon the listener's acceptance of it. By utilizing a larger number of judging sessions, it would be possible to eliminate possible order effects by varying the order of modes of presentation and the sequential presentation of the types of postlaryngectomy speech.
CHAPTER V

SUMMARY

The purpose of this study was to investigate the effect of auditory and combined auditory-visual cues upon the judged intelligibility of esophageal speech and of artificial larynx speech, and to determine if auditory and combined auditory-visual cues differentially affect the judged intelligibility of these two methods of postlaryngectomy speech. The major objective of the formulation of this purpose was to provide a means of investigating the visual aspects of postlaryngectomy speech.

Simultaneously tape recorded and filmed samples of postlaryngectomy speech, seven samples of esophageal speech and an equal number of artificial larynx speech samples, constituted the stimulus material that was presented to 38 judges during two judging sessions. It was the task of the judges to rate the intelligibility of each speech sample twice during each judging session, once under each mode of presentation, auditory and combined auditory-visual. Intelligibility was rated on a seven point equal appearing intervals scale.

The results of the first judging session indicated that auditory and combined auditory-visual cues differentially affected the judged intelligibility of these two types of speech. It appeared that combined auditory-visual cues increased the intelligibility of esophageal
speech while serving to reduce the intelligibility of artificial larynx speech. However, the direction of this differential effect of mode of presentation was reversed during the second judging session when the order of the modes of presentation was reversed. This suggested that the findings of the first judging session may have been, at least in part, due to the influence of an order effect.

Therefore, it was concluded that on the basis of the present study there is a lack of convincing evidence that visual cues importantly affect judgments of intelligibility of postlaryngectomy speech. While auditory and combined auditory-visual cues may differentially affect the judged intelligibility of esophageal speech and artificial larynx speech with the initial exposure to these types of speech, it may be hypothesized that with continued exposure, this differential effect becomes less potent.

It was further concluded that the results of the present study provide little evidence that the obvious use of a mechanical device reduces the communicative effectiveness of speech produced by this means.
BIBLIOGRAPHY
BIBLIOGRAPHY


17. Lueders, O. W., Use of the electrolarynx in speech rehabilitation. Archives of Otolaryngology, 63, 1956, 133-134.


INSTRUCTIONS TO THE JUDGES AND RATING SHEET

This is a research project in which you are to judge the relative intelligibility of speech used by persons who have undergone surgical removal of the larynx. They will be using two methods of what is sometimes called "substitute voice". You can, therefore, expect that the speech will sound somewhat different from what might be called "normal" speech.

You will be listening to 14 speakers on sound film and 14 tape recorded speech samples. The speakers will be reading the paragraph which you were asked to read over when you came into the room.

When we start the experiment you are to rate the speakers in terms of the intelligibility, or understandability, of their speech. In other words, you are to rate each speaker in terms of how well you can understand what he is saying.

This is an example of the rating sheets you will use to record your ratings. (Hold up sheet and explain.)

Number 1 represents the lowest degree of intelligibility. If you consider a speaker to be unintelligible, hard to understand, you will give him a rating of 1.

Number 7 represents the highest degree of intelligibility. If you consider a speaker to be very intelligible, easily understood, you will rate him 7.

Number 4 on the scale represents the mid-point between intelligibility and unintelligibility, or average intelligibility.

We are going to begin today by asking you to rate the speakers
in a film (on a tape). You will have time to rate each speaker after he is finished speaking. Circle the number that indicates your rating. Remember, number 4 indicates average intelligibility. Less than average speakers, or speakers who you feel are difficult to understand, should be rated 1, 2, or 3. Speakers who are better than average in terms of intelligibility should be rated 5, 6, or 7.

We are now ready to begin. Please turn to your first rating sheet. It is the sheet with the caption "Condition I" at the top of the page.

Before you start your ratings, you will hear samples of speech representing the two extremes of the rating scale. The first sample is very intelligible and would be given a number 7 rating. (Play example.) This next sample of speech is relatively unintelligible and would be rated number 1. (Play example.) You will now hear seven speech samples. Rate each of them 1 to 7 in terms of intelligibility. Be sure to rate each speaker. Be sure you have at least one rating of 1 and one rating of 7 among all of your judgments.
CONDITION I

Speaker No. 1

1 2 3 4 5 6 7

Speaker No. 2

1 2 3 4 5 6 7

Speaker No. 3

1 2 3 4 5 6 7

Speaker No. 4

1 2 3 4 5 6 7

Speaker No. 5

1 2 3 4 5 6 7

Speaker No. 6

1 2 3 4 5 6 7

Speaker No. 7

1 2 3 4 5 6 7
APPENDIX B
INDIVIDUAL AND GROUP MEAN JUDGED INTELLIGIBILITY RATINGS FOR TWO JUDGING SESSIONS

<table>
<thead>
<tr>
<th>Speakers</th>
<th>Esophageal Speech</th>
<th></th>
<th>Artificial Larynx Speech</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Session I</td>
<td>Session II</td>
<td>Session I</td>
<td>Session II</td>
</tr>
<tr>
<td>1</td>
<td>3.03</td>
<td>3.26</td>
<td>4.00</td>
<td>4.79</td>
</tr>
<tr>
<td>2</td>
<td>1.89</td>
<td>3.37</td>
<td>3.24</td>
<td>3.26</td>
</tr>
<tr>
<td>3</td>
<td>3.97</td>
<td>3.97</td>
<td>5.11</td>
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<td>4</td>
<td>3.11</td>
<td>3.76</td>
<td>4.39</td>
<td>3.39</td>
</tr>
<tr>
<td>5</td>
<td>6.76</td>
<td>6.18</td>
<td>6.92</td>
<td>6.76</td>
</tr>
<tr>
<td>6</td>
<td>5.05</td>
<td>5.32</td>
<td>6.16</td>
<td>5.29</td>
</tr>
<tr>
<td>7</td>
<td>4.29</td>
<td>4.76</td>
<td>4.76</td>
<td>4.37</td>
</tr>
<tr>
<td>Means</td>
<td>4.01</td>
<td>4.37</td>
<td>4.94</td>
<td>4.63</td>
</tr>
</tbody>
</table>