SEX IDENTIFICATION FROM ARTIFICIAL ALARYNGEAL SPEECH

David E. Hartman
Department of Communicative Disorders
College of Saint Teresa

and

Kathleen Corrigan
Department of Communicative Disorders
College of Saint Teresa

ABSTRACT

Two speakers, a male and a female, used two models of an electronic artificial larynx as the vocal sound source. Fifty male and 50 female untrained listeners made judgments of sex from samples of artificial alaryngeal speech. The results indicated that (1) the judgments of the listeners differed significantly dependent upon the model of instrument used, and (2) when the sound source varied, the male speaker was accurately perceived as being male, while the female speaker was judged as being either male or female. The findings were explained in terms of differences in vocal tract characteristics found in men and women. Recommendations were made as to the model of artificial larynx to be used by male and female laryngectomees in order to better maintain sexual identity.

It has been shown that listeners are able to differentiate the sex of a speaker on the basis of a minute speech stimuli such as an isolated consonant (Schwartz, 1968). This skill appears to be maintained even when the vocal tract is altered, such as by laryngectomy, or when a modified electronic artificial larynx is used as the vocal sound source for laryngeal speakers (Weinberg, et al., 1971; Coleman, 1971).

One theme noted in the literature concerned with speech rehabilitation following laryngectomy, is the emphasis on acquisition of a form of alaryngeal phonation which will maintain sexual identity, especially for women (Putney, 1958; Gardner, 1966). It may be assumed from previous research that both esophageal speech, and alaryngeal speech produced with an artificial sound source, allow for accurate perception of sex by listeners. However, in the latter case, the nature of the sound generator would appear to be a viable factor in the perception of sex by listeners. The Western Electric Company has given consideration to this matter in the design of the Model 5A and 5B electronic artificial larynges, for male and female alaryngeal speakers. [1]

The purpose of this study was to systematically analyze the responses of listeners to artificial alaryngeal speech as produced by the Model 5A and 5B electronic artificial larynges.

[1] **Instruction Manual**, Western Electric No. 5 type electronic artificial larynx, Western Electric Company.

METHOD

Fifty male and 50 female college students with little or no experience with listening studies, or the field of speech pathology, served as listeners. None of the subjects reported hearing problems.

Two speech pathologists, a male and a female, with normal speech mechanisms, and demonstrated speaking proficiency with an electronic artificial larynx served as speakers. The average fundamental frequency (f_0) of the male speaker was 112.5 Hz, and 240 Hz for the female speaker. The Western Electric Electronic Artificial Larynges Model 5A and 5B, modified to produce a steady sound at 90 Hz and 165 Hz respectively, were used by both speakers as the vocal sound source. Each speaker read the first seven lines of the "Rainbow Passage" twice, once using the 5A instrument and once using the 5B. To test intra-judge reliability, a reading sample was selected and duplicated for one speaker using each of the instruments. Speech samples were recorded on a Sony Model TC-104A tape recorder using an Electro-Voice Model 638 microphone. The six taped samples were separated and spliced at random to form the experimental listening tape.

For the experiment, each listener was provided with a response sheet, a written transcription of the speech sample, and verbal and written instructions of the task. The listening stimuli were presented free-field at a comfortable loudness level, approximately 70 dB, incorporating the same system used for recording of the speech samples. Listeners were allowed five seconds to make a judgments of speaker sex from each sample.

RESULTS

Three observations may be made from the data. First, male and female listeners were certain of their perceptual judgments. Second, the judgments of the listeners differed depending upon the model of artificial larynx used. Third, both male and female listeners were accurate in identifying the sex of the male speaker regardless of the instrument used. However, the female speaker was significantly identified as a female when using the 5B.

The Person product-moment correlation coefficient (Bruning and Kintz, 1968) was used to test intra-judge reliability for the listening task. The results indicated a value of .99 for both male and female listeners for the two original and duplicated speech samples, indicating a high degree of judgment reliability for the experiment.

A chi square test (Ferguson, 1971) showed a significant difference between the judgments of listeners as to the sex of the speaker, based upon the model of artificial larynx used (with 3 df, $X^2 = 150.21$, $P < .001$).

A second chi square analysis was used to determine if there was a significant difference between the judgments of listeners for each speaker in both conditions. The results indicated no significant difference for the judgments of the male speaker (with 1 df, $X^2 = 2.45$, $p > .001$), and a significant difference for the judgments of the female speaker (with 1 df, $X^2 = 24.62$, $p < .001$). These findings can be explained by observing that the male speaker was consistently judged as a male whether using either model of artificial larynx, whereas the female speaker was judged as a male when using Model 5A, and a female using the 5B, a majority of the time. It should be noted, however, that the incidence of accurate responses was less for the female

speaker when she used the 5B instrument, than when the male speaker used the 5A. Table 1 presents the number and percent of correct sex identifications made by the listeners for the speakers using the two artificial larynges.

TABLE 1. Correct Sex Identifications of 50 Male and 50 Female Listeners to Four Alaryngeal Speaking Conditions.

	Male Speaker		Female Speaker	
Sex of Listener	Using Model 5A	Using Model 5B	Using Model 5A	Using Model 5B
Male	48 (96%)	48 (96%)	13 (26%)	33 (66%)
Female	49 (98%)	48 (96%)	16 (32%)	31 (62%)

DISCUSSION

The results of this experiment show that untrained male and female listeners agree about the sex of a speaker when either the Model 5A or 5B Western Electric artificial larynx is used as the vocal sound source. Furthermore, the model of instrument is a significant factor in the nature of the judgments made by this population of listeners when the speakers are not a variable. When they are considered a variable, the model of instrument is not a factor in accurately identifying a male speaker, but is a variable in the perception of a female. The results for the male speaker are in contradiction to Western Electric's recommendation for use of only the 5A artificial larynx by male alaryngeal speakers.

A possible explanation for these findings could lie in the differences in vocal tract characteristics found in men and women, and the influence of these differences on the identification of speaker sex. Coleman (1976) found that when male vocal tract resonance was coupled with a female fundamental frequency, or a female vocal tract resonance was paired with a male fundamental frequency, listeners usually judged the speaker to be male. It was concluded, therefore, that the two male characteristics of voice had greater perceptual prominence for sex identification by listeners than comparable female features.

The results of the present investigation are similar to those of Coleman. When the male and female speaker used the 5A artificial larynx, both were judged to be male a majority of the time. For the male speaker, this finding was apparently due to vocal tract resonance characteristics and the pitch of the instrument itself. The judgments of maleness for the female speaker, however, appeared to be based on the pitch of the instrument, thus reflecting the dominance of this male feature of low pitch.

Using Model 5B, the results are somewhat confounded. For the male speaker, judgments were again based on vocal tract resonance features and the pitch level of the instrument. By examining the differences between the actual f_0 of each speaker and the pitch of each instrument, it is apparent that the tone of the 5B is closer to the average f_0 if the male speaker. Because of this situation, it is not possible to conclude that vocal tract resonance features exclusively caused judgments of maleness in this

condition. However, it could be suggested that they were dominant perceptual features, in that the 5B instrument was pitched higher than the 5A.

For the female speaker using the 5B, it is interesting to note the accuracy of judgments of sex even though the instrument was pitched closer to the male f_0. Judgments for this speaker were possibly based upon unique features of the female glottis and associated structures (Coleman, 1976), and vocal tract resonance characteristics. This instrument also permitted a better situation for a judgment of femininity: the higher pitched instrument paired with the higher vocal tract resonance features. Further research is warranted in order to substantiate these conclusions.

An inherent problem in substituting an artificial larynx for normal laryngeal tone is that the trachea can alter vocal tract resonance characteristics because of acoustical coupling with the remainder of the system (Coleman, 1976). Therefore further research is planned with alaryngeal speakers using both models of the Western Electric instrument in order to offer additional substantiation to the present investigation.

CONCLUSION

The results of this investigation may have implications for those who engage in laryngectomee rehabilitation. First, in the case of a male patient, either the Western Electric Model 5A or 5B Electronic Artificial Larynx, or comparable instruments produced by different manufacturers, should allow for maintenance of sexual identity from speech. Second, for a female patient, Model 5B, or a comparable device, may maintain feminine recognition, although the possibility remains that she could be misidentified as a man. In both instances, clients should be informed of the possible reactions of listeners to artificially produced alaryngeal speech. Since these reactions tend to be superficial in nature, clients should be instructed about how to react to them (Hartman and Scott, 1974).

Address correspondence to:

David E. Hartman, Ph.D.
Department of Communicative Disorders
College of Saint Teresa
Winona, Minnesota 55987 U.S.A.

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